GEOLOGICAL SURVEY OF GEORGIA

W. S. YEATES, State Geologist

BULLETIN No. 1

A

Preliminary Report

on the

Marbles

OF

GEORGIA

BY

S. W. McCALLIE

Assistant Geologist

1894

GEO. W. HARRISON, State Printer

Atlanta, Georgia

With the Compliments of . . . . .

The State Geologist.

MARBLE BLUFF, GILMER COUNTY, GEORGIA.

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ERRATA.

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1. On page 17, 19th line, for "find of valuable experience," read *fund of valuable experience.*

2. On page 22, under figure 1, 3rd line, for "their beds of quartzite," read *thin beds of quartzite.*

3. On page 50, 13th line, for "near Hollow Spring," read *near Holly Spring.*

4. On page 69, 11th line, for "The Ingersol Golding Machine," read *The Ingersol Gadding Machine.*

5. On page 73, 28th line, for "the lower end," read *the lower edge.*

6. On page 86, 4th paragraph, lines 3 and 4, for "from three to five per cent.," read *from .3 to .5 per cent.*

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Of the Geological Survey of Georgia.

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STATE OF GEORGIA, GEOLOGICAL SURVEY.
ATLANTA, GA., August 20, 1894.

To His Excellency, W. J. Northen, Governor, and President of the Advisory Board of the Geological Survey of Georgia,

SIR:—I have the honor to transmit, herewith, the report of Mr. S. W. McCallie, Assistant Geologist, on "The Marbles of Georgia." This is the first of a series of bulletins, intended to give the latest and most reliable information on the various subjects embraced in the economic geology of the State. As new information is to be expected, wherever development is undertaken, and as new localities for minerals are liable to be found at any time, these economic reports are to be considered preliminary and subject to emendation, either by supplemental bulletins, or when the final reports on the general geology of the State shall be undertaken.

Very respectfully yours,
W. S. YEATES,
State Geologist.

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THE MARBLES OF GEORGIA.

CHAPTER I.

A HISTORICAL SKETCH OF THE DEVELOPMENT OF THE MARBLE INDUSTRY IN PICKENS COUNTY, GEORGIA.

In 1840, Fritz T. Simmons began quarrying marble on a small scale, in Longswamp valley near Tate. This seems to have been the first systematic work, done in the county, toward developing the marbles. Previous to this time, however, the Cherokee Indians, who originally inhabited this section of the country, worked the marble, to a limited extent, into bowls and various other forms. A good specimen of this handiwork may still be seen, in the form of a large circular marble bowl, now used as a flower pot in Colonel Stephen Tate's yard, near the Southern and Piedmont quarries. It is remarkably well preserved, and is prized very highly by its present owner.

The stone worked by Simmons, is said to have been obtained from outcroppings and weathered bowlders, exposed along the hillside, and was not always of the best quality. The impure and more or less laminated varieties were frequently selected, on account of the ease with which they could be worked. At first all the work required in getting out and polishing the stone, which was then used exclusively for tombstones, was executed by hand. The great amount of manual labor thus spent on the stones, before they were ready for erection in churchyards, made them so costly, that only the wealthy were able to buy; and, as a result, the demand was so limited that only a few hands were necessary to supply the trade. About two years after Simmons began work, he erected a mill with one gang of saws, on the east branch of Longswamp creek, near Marble Hill post-office. This was the first mill put up in the county for sawing marble. This mill, as a whole, is said to have been a somewhat prim-

itive affair; but the mode of cutting the marble was the same as is now employed in our best mills. A short time after this, another mill was built by Simmons and Hurlick on the west branch of Longswamp creek, two miles east of Jasper. It was run, though not continuously, for four or five years, when work in both the mill and the quarry located near by was temporarily suspended. Mr. Simmons, who had now associated with him, as a partner, Mr. Margum of Marietta, began work on a more extensive scale at the original quarry, near which the Southern Marble works are now located. The firm continued operations for only a few years; but, during that time, it got out a great many tombstones, many of which can be seen in churchyards throughout the surrounding country.

In 1850, Tate, Adkinson & Co. opened a quarry in the vicinity of the Georgia Marble works, and erected two mills on the creek, one above and the other, below the quarry. Each mill had two gangs of saws, which enabled the company to turn out a greater amount of work than any previously organized. Owing to this increased facility for the production of marble, the firm now found it necessary to employ an agent to travel through the counties of North Georgia, to solicit orders for tombstones. When a number of these stones, sufficient to make a wagon-load, had been sold, a delivery wagon, drawn by six mules, was started out on the road, to deliver the stones to the respective buyers, as it traveled through the country. This mode of transportation, in a mountainous country, where the roads were usually rough and steep, added greatly to the original cost of the stone. Common, plain tombstones, that now bring from ten to twelve dollars per set, then sold at thirty or forty dollars. After continuing operations for only about two years, this firm was succeeded by Rankin, Summy & Hurlick, which was the last company to do any work, in the immediate vicinity of the Georgia Marble-works, until the present company was organized. In 1854, Summy & Hurlick, who, ten years before, had opened a quarry two miles east of Jasper, again renewed the work at that place. They erected there a mill with four gangs of saws, and continued successful operation for about six years, when the works were abandoned, on account of the late war. Immediately after the war, the quarry was worked by Robinson, Richardson & Besinger, for nearly two years;

but it was afterward abandoned, until 1885, when the property fell into the hands of the Perseverance Marble Company, organized by Jas. P. Harrison and others. This company at once made a considerable outlay of money, in erecting a steam-mill, opening up new quarries, etc. Steam-drills and all the machinery necessary to carry on a first-class quarry were secured. The works, which now employed a number of hands, continued operations for only about three years, turning out, in the meantime, a great deal of marble, which was used for various purposes. Since then, the greater part of the machinery has been removed, and the buildings have become somewhat dilapidated.

THE GEORGIA MARBLE COMPANY was organized in May, 1884, with a capital of $1,500,000. This date marks the beginning of a very important epoch, in the history of the development of the marble industry in Pickens county. Previous to this time, Georgia marble was practically unknown to the trade as a building-stone, and had even a very local use for tombstones etc.; but, on account of the superior quality of the marble, and the energy and business-like methods of this and other companies soon organized, it has found its way to all parts of the United States, where it is now used in the construction of some of the most costly buildings. The first work of the Georgia Marble Company, after securing control of nearly seven thousand acres, was to construct and equip a branch railroad from the quarries to the main line of the Marietta and North Georgia Railroad. This gave ready means of transportation to all parts of the country. The mills and quarries were then put in operation, at a total cost of nearly $800,000, and have been run continuously ever since, with a gradually increasing output.

THE SOUTHERN MARBLE QUARRIES were opened in 1885 by Miles & Horne, contractors for the State capitol of Georgia. The stair-steps and the tiling, except the border tiles, used in this building, were secured at these works. Since then the facilities for quarrying and working the marble have been greatly increased. New quarries have been opened, and mills erected; and great quantities of white marble have been annually shipped to all sections of the country for monumental work and interior finish. During the same year, in which the Southern marble quarries were opened, Geo. B. Sickels & Co., marble dressers, near Tate, began work. This firm has since gradually

increased its output, from year to year, until it has built up an extensive trade in tiling and interior decoration.

THE PIEDMONT AND THE BLUE RIDGE MARBLE COMPANIES were both organized in 1886. The former opened a quarry and erected a large mill near the Southern works; but, for some reason, the works have not been continuously operated. The firm, at present, however, has some large buildings under contract, and is doing quite an extensive business. Since the last named date, no new plants have been put in operation; but the old firms have each gradually increased their output, until Georgia, as shown by the following table from the report on the mineral resources of the United States for 1893, has become the most extensive marble producing State in the Union, with the exception of Vermont only:—

PRODUCTION OF MARBLE IN 1893, BY STATES.

STATES.	VALUE.
Vermont	$1,621,000
Georgia	261,666
New York	206,926
Tennessee	150,000
Maryland	130,000
Pennsylvania	27,000
California	10,000
Idaho	4,500
Total	$2,411,092

CHAPTER II.

THE ORIGIN OF LIMESTONES.

In order that the general reader may better understand the position and mode of occurrence of the Georgia marbles, it is thought advisable to give a short sketch of the origin of limestones. The term limestone embraces all calcareous rocks, however soft or hard. It includes the soft, friable chalks, as well as the hard, crystalline marbles.

Limestones have been formed, either as a precipitate from a saturated solution of calcium carbonate, or from the remains of shells and skeletons of animals. It has been the prevailing opinion, among scientific men, until quite recently, that all extensive calcareous formations have resulted from the débris of organisms. This opinion is now considered by some of our leading geologists to be far too sweeping, and they have presented many facts, which make it quite probable that many of our limestones are partly, and some of them, entirely, due to chemical precipitation.

The everglades of Florida are said to present favorable conditions, for the deposition of calcareous matter from chemical solution. They form an extensive swamp, with an area of several hundred square miles, elevated only a few feet above the sea-level. During the rainy season, the swamp is submerged by the swollen rivers, which flow into it. The waters of these rivers, being collected from soils where vegetable matter is undergoing decomposition, contain much carbonic acid, which enables them to take into solution a great deal of calcium carbonate, dissolved from the calcareous rocks, over which they flow. In the dry season, the water of the swamp, exposed to the rays of a subtropical sun, undergoes a rapid evaporation, and deposits calcium carbonate, both as a calcareous mud and in a crystalline form. The deposit extends over a considerable area, almost horizontal; and, if the conditions, now in existence, were to continue, for a long period of time, the formation would attain a thickness of

many feet, and would require only to be consolidated, in order to form an extensive bed of what is commonly called limestone.

Many of the rivers, flowing into the Mediterranean sea, also deposit on the sea bottom, opposite their mouths, calcium carbonate as a chemical precipitate. The calcareous deposit is especially abundant at the mouth of the river Rhone, and has been pointed out, by Sir Charles Lyell and others, as an example of hard, compact, calcareous rock, now in process of formation. There may be seen, in the Museum of Montpelier, France, a cannon taken from the sea bottom, near the mouth of this river, embedded in a crystalline calcareous rock, that shows both the character and the recent origin of the deposit.

In all countries, limestone is being deposited, as a chemical precipitate, about the outlet and along the course of limestone springs. Probably the best examples of this mode of forming calcareous rocks are to be found in France and Italy, where, at places, large areas are covered to the depth of many feet by the deposit. In this country we are having similar deposits laid down by the "Old Sweet" and the "Red Sweet" springs of Virginia; and, also, by numerous springs in California and the Yellowstone region. Notable are the deposits made by the celebrated Mammoth Hot Springs in the Yellowstone National Park, where immense deposits of calcareous tufa are rapidly forming. The rocks thus formed are not usually very extensive, as compared with other deposits; but, nevertheless, they are frequently important, from an economic standpoint. Owing to the peculiar condition, under which they are formed, they often show quite a variety of colors arranged in bands, which make the stone very valuable for ornamental purposes, when sufficiently compact. The so-called California, Missouri, Arizona, and Mexican onyx, calcareous stones of remarkable beauty, were probably deposited in this way.

Limestone, resulting from chemical precipitation, appears to be confined, at present, almost entirely to land-locked lagoons, bays, and running streams; but, during the earlier geological times, when the earth's crust was at a much higher temperature, it was probably deposited more or less abundantly in the open sea. This seems to be the only explanation, for limestones being found in Archæan areas.

Animals, from a very early period in the history of the earth, have

been the most effective agents in the formation of limestone. They have worked continuously in the waters of all latitudes, extracting from the sea-water the calcareous matter carried down by rivers, and forming it into hard shells and skeletons. The accumulation of their remains, in the course of generations, formed thick beds, extending over wide areas. If these remains accumulated in a bay or estuary, where they were protected from the action of the waves, the rock resulting from their consolidation would consist of a mass of shells and skeletons, probably cemented together by a thin layer of calcareous mud. On the other hand, if they accumulated on an exposed coast, the waves would pulverize them into a fine powder, which, when consolidated, would form a compact limestone, rarely showing any trace of the shells, from which it was formed.

Along the southern coast of Florida, immense beds of limestone are now in process of formation from the remains of animals. There, as elsewhere in all temperate and tropical seas, the most active lime-producing animals are the corals. All the southern portion of that State has been formed, mainly, from the débris of these organisms, which are still extending it seaward.

The conditions for the rapid growth of these animals appear to be even more favorable about the islands of the South Pacific, where thousands of square miles of the ocean's bed are covered to the depth of many feet by their remains, which in many places have become so hard and compact, as to form calcareous rocks, difficult to distinguish from the more ancient limestones.

On submarine banks and in shallow seas, not suitable for the growth of corals, echinoderms, crustaceans and mollusks live in great numbers. The hard parts of these animals, being principally calcium carbonate, are piled up, in process of time, into extensive heaps, which gradually become consolidated into rock, sufficiently firm for building purposes, although many of the shells may still retain their original structure and delicate markings.

In the deep sea, there exist, near the surface of the water, myriads of microscopic organisms, whose calcareous skeletons are continually falling to the bottom, where they form at places a thick deposit of ooze, closely resembling pulverized chalk. Recent investigations show that deep-sea ooze and chalk are almost identical, and were

likely deposited under similar conditions, as the remains of very minute animals.

All limestone, making up a portion of the earth's crust, has been made by the same chemical or organic agencies, which are still in operation, forming calcareous deposits. So completely has this fact been established, that, in many instances, the whole series of changes can be traced from the loose heap of shells on the sea bottom to the hard crystalline marbles on the mountain side. These, as well as all other sedimentary deposits, when first laid down in the ocean by the action of water, were originally horizontal; and, if the existing conditions had not changed, they might have continued to increase indefinitely, both in thickness and extent. The crust of the earth, however, was very unstable, and underwent, from time to time, great changes, which brought about corresponding changes in the nature of the deposits. Clear seas, once teeming with innumerable lime-producing animals, were gradually changed into muddy seas, depositing clay, sand, and gravel. These various sediments, together with the calcareous beds, were many times repeated, until they attained an aggregate thickness of many thousand feet. Then lateral pressure, which had been increasing for ages, as the earth contracted from the loss of heat, caused the horizontal beds to be slowly raised above the surface of the ocean, and sometimes to be bent into gigantic folds, forming alternate valleys and ridges. So powerful were these lateral forces in many cases, that the folds overlapped one another, or broke and relieved the tension, by thrusting one edge of the series of strata far over the other.

During sedimentation and upheaval, heat, pressure and chemical action almost universally changed the deposit into compact rocks, such as are now to be seen outcropping on nearly every hillside in North Georgia. As soon as these indurated deposits were elevated above the sea-level, atmospheric and aqueous agencies began their work of erosion and transportation. The folds, forming high ridges and even mountains, were often cut away by these agents into valleys, while the valleys remained as ridges. The original natural features of the country were thus, in many cases, completely changed, and the former topography can now be worked out, with any degree of certainty, only after a thorough knowledge of the structural geology

PLATE II

Marble Quarry, near Mineral Bluff, Fannin County, Georgia.

of the region. No section of the country, probably, better illustrates this advanced stage of folding and erosion, than that portion of North Georgia, in which the beds of crystalline limestones, or marbles, appear. Here the various contorted and folded strata of slate, gneiss, conglomerate and marble, once horizontal beds of clay, sand, gravel, and calcareous material in the bottom of the sea, now dip at an angle from 20° to 70° to the southeast. This direction of dip is practically the same throughout the marble belt, and is evidently due to close pressed, overlapping folds, with their upper portion removed by erosion. As the relative positions of the different beds of rocks in a fold always remain unchanged, it is possible to trace certain strata, as marble, long distances, without ever seeing any actual outcrop, and even to identify a stratum as belonging to the same geological horizon, though the outcroppings may be many miles apart. Where marbles underlie valleys covered to considerable depths, as in North Georgia, this is the only way that they can be located, with any degree of certainty; and the prospector who disregards these facts usually retires from the field with only a large find of valuable experience as a reward for his labor.

Limestones resulting either from chemical precipitation or from the remains of animals, differ greatly, both in chemical and physical properties. These differences have given rise to many varieties; the principal ones are described below :—

Common limestone is a compact, massive rock, occurring in beds or layers, with other sedimentary deposits, and is the most abundant of all the calcareous rocks. Its color is commonly yellowish gray, blue, or brown; but it may be black, or even red. It, like all other rocks of this class except dolomite, effervesces readily with dilute hydrochloric acid, burns readily into quicklime, and may or may not contain animal remains. Most common limestones are crypto-crystalline.

Marble, which is the special subject of this report, differs from the common limestone only in being pheno-crystalline. It is made up of crystalline grains of a uniform size, but usually of no definite shape; these may readily be seen with the naked eye, as the name pheno-crystalline implies. When free from foreign substances, marble is of a snow-white color; but, if accessory minerals are present, the stone

may be red, blue, yellow, gray, green, or black. This great variety of colors well adapts it for all classes of ornamental work. It occurs, like common limestone, in immense beds, sometimes hundreds of feet in thickness and many miles in length; but, unfortunately, only a small proportion of such deposits furnish stone of any economic value. Marble is regarded by many geologists as a metamorphic rock, and has, in most cases, been produced, probably, from common limestone, by means of heat and pressure.

Magnesian limestone (dolomite) is a very abundant calcareous rock, closely resembling common limestone, in all its physical properties, but having a different chemical composition. When pure, it is composed of nearly equal parts of calcium carbonate and magnesium carbonate; and, unless heated, it does not readily effervesce with dilute hydrochloric acid. Magnesian limestone occurs both as a pheno-crystalline and a crypto-crystalline rock. When pheno-crystalline, it is called a dolomitic marble, and makes a fine stone, either for ornamental or for architectural purposes. The crypto-crystalline form of this rock occurs in Northwest Georgia as Knox dolomite, where it forms a number of wide, more or less parallel bands, extending in a diagonal direction across the corner of the State. It has been used at several places for bridge piers, retaining walls, etc.; but, as it does not admit of a fine polish, it cannot be used for ornamental purposes. The crystalline form appears as a true dolomitic marble, at various places along the marble belt in Pickens, Gilmer, and Fannin counties.

Oölitic limestone consists of small, more or less spherical grains of calcite, cemented together by similar material; it resembles somewhat the roe of a fish, receiving its name from this resemblance. The individual grains have a concretionary structure, which has resulted from the peculiar conditions, under which they were deposited. The better qualities of the stone are well adapted for building purposes. The State capitol of Georgia is constructed of this variety of limestone, from Indiana.

Crinoidal limestone is made up almost entirely of crinoidal stems, corals etc. It is frequently semi-crystalline; and, when variegated, as the Tennessee marble, it makes a remarkably fine ornamental stone.

Travertine is deposited, as a chemical precipitate, by springs or

streams, and varies greatly in color and texture. Its color is usually white or some shade of brown, green, red, or yellow. In the more compact varieties of the stone, as the so-called Mexican onyx, these different colors alternate with each other, producing a beautiful banded structure. When travertine is deposited in water much agitated, it is quite spongy and porous, and has no economic value, either as a building or ornamental stone. This variety is called tufa. *Stalactites and stalagmites*, cave deposits, have an origin similar to that of travertine.

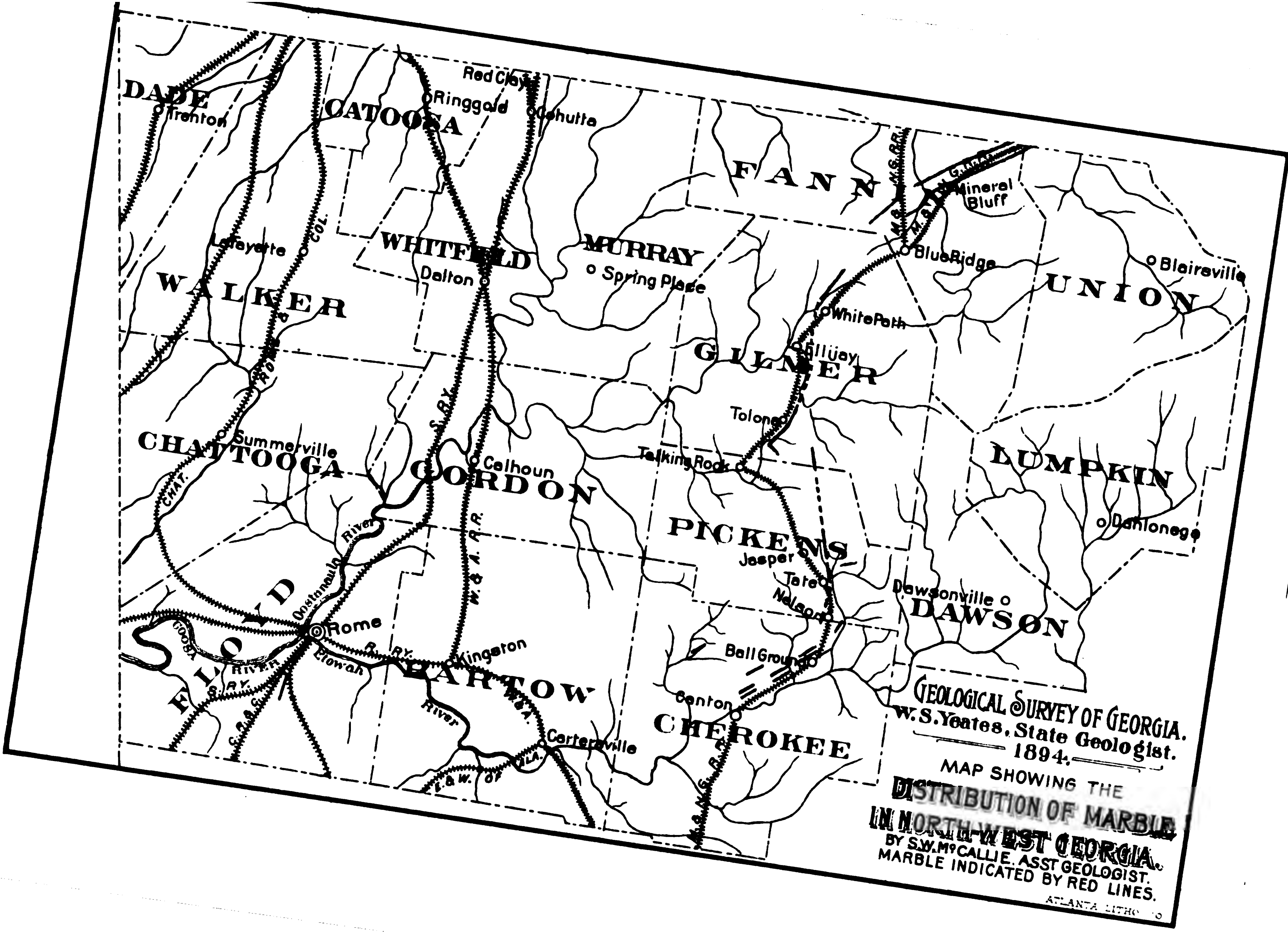
Hydraulic limestone is an impure calcareous rock of various colors, found more or less abundant in all geological formations. It contains clay and silica, which are often found in such abundance, that, when the rock is burnt for lime, it will not slack with water; but, when ground and mixed as a mortar, it will set under water, and form a mass of great hardness. Hence it is called hydraulic limestone. The best varieties of this stone are generally found as transitional beds between ordinary limestones and shales or sandstones.

Chalk is a fine-grained, earthy limestone, so soft as to readily soil the hands. It often encloses nodules or bands of flint; and, when examined through the microscope, it is frequently found to be made up largely of shells of very minute animals.

Lithographic limestone is a very compact, fine grained, homogeneous calcareous rock, usually of a pale-gray or yellowish color, with a conchoidal fracture. It is extensively used by lithographers for making maps etc. On the smooth surface of such a stone, drawings are made with a greasy ink, specially prepared for the purpose; or such a drawing may be transferred to the stone directly from the original drawing. The stone, being somewhat porous, retains the ink; and, if it is now moistened with water, all parts of the stone become wet, except where the grease occurs. A roller, coated with printer's ink, is then passed over the stone, taking effect only on the greased lines of the drawing, which may then be printed from, as from an engraving. There are only a few places, so far discovered, within the United States, where limestone occurs, possessing the necessary qualities for lithographic purposes, nearly all of it, at present, being imported from Solenhofen, Bavaria.

Bituminous or fetid limestone is usually of a very dark color; and,

when struck with a hammer, it gives off a very disagreeable odor, which appears to be due to the carbonaceous material it contains. When exposed to the atmospheric agencies for any length of time, it undergoes a change in color, frequently becoming almost white on the exposed surface. The so-called black marbles of Cedar Ridge, Murray county, are good examples of bituminous limestone.


GEOLOGICAL SURVEY OF GEORGIA.
W. S. Yeates, State Geologist.
1894.
MAP SHOWING THE
DISTRIBUTION OF MARBLE
IN NORTH-WEST GEORGIA.
BY S. W. McCALLIE. ASST GEOLOGIST.
MARBLE INDICATED BY RED LINES.
DADE
Trenton
CATOOSA
Ringgold
Red Clay
Cohutta
WHITFIELD
Dalton
MURRAY
Spring Place
FANNIN
Mineral Bluff
Blue Ridge
UNION
Blaireville
WALKER
Lafayette
GILMER
White Path
Ellijay
Tolona
CHATTOOGA
Summerville
GORDON
Calhoun
Talking Rock
LUMPKIN
Dahlonega
PICKENS
Jasper
Tate
Nelson
Dawsonville
DAWSON
FLOYD
Rome
Oostanaula River
Etowah
Kingston
BARTOW
Cartersville
River
Ball Ground
Canton
CHEROKEE

CHAPTER III.

THE MARBLES OF FANNIN COUNTY.

All the true marble of Georgia, so far discovered, appears in a narrow belt, sixty miles long, extending in a northeastern and southwestern direction through Fannin, Gilmer, Pickens, and Cherokee counties, which lie in the northern part of the State, on the border line between the well-known Paleozoic group and the broad belt of crystalline rocks. That portion of the counties where the marbles are found is usually quite hilly, and in places, even mountainous, with peaks reaching an altitude of more than four thousand feet above the sea-level. The numerous valleys are narrow, but very fertile, while the adjacent ridges are generally unproductive, unless underlaid by black slate or marble, which invariably weathers into a rich soil, heavily timbered with oak, chestnut, poplar, hickory, and other species. The trend of the valleys and ridges is generally northeast and southwest, corresponding in direction to the strike of the strata. However, they are subject to local variations, especially in the region of the great mountain masses in Pickens and Gilmer counties.

Living streams are everywhere abundant; and the large ones are frequently rapid, and furnish fine water-power, which is at present almost unutilized.

The Marietta and North Georgia Railroad runs parallel with the marble belt, throughout its entire length; and at no point is the outcropping located more than two or three miles from this road.

The marbles enter the extreme northeastern portion of Fannin county from North Carolina in two almost parallel lines of outcroppings, located about two miles apart, and extending in a diagonal direction across the county. The line of outcropping, lying furthest to the east, makes its first appearance on the head-waters of HAME STRING CREEK (*lot* 45, *8th district, 1st section*), a small stream flowing to the northeast, and emptying into the Notteley river. The exposure here is at the juncture of two small ravines, and consists of a few large bowlders of disintegration, with their surface much

Fig. 1.

A three mile section from Watson's mountain, on the left, to High Top, showing the kinds and the position of the strata interstratified with the marble. 1. Gneiss and mica schist. 2. Marble. 3. Black mica and gneiss interstratified with their beds of quartzite. 4. Greenish hydro-mica slate.

weathered. Nothing has been done towards the development of this property, and but little is known of the general character and extent of the deposit. The specimens secured are made up of small crystalline grains, and are of dark or light gray color. There is almost an entire absence of the mica, which produces the laminated structure, so frequently seen in many of the fine-grained marbles of North Georgia.

The rocks, associated with the marbles[1] on the east, are gneisses, interstratified with thin beds of metamorphic sandstone, and give rise to a series of high ridges and knobs, extending as far south as Hemptown creek. The rocks, associated with the marbles on the west, are greenish hydro-mica slates, overlaid by gneisses and mica-schist, and forming the less elevated ridges and hills, that separate the two lines of marble outcroppings.

The dip of the rocks here, as elsewhere throughout the marble belt of Fannin county, is generally to the southeast, at an angle of from 30° to 70°, though they are subject to many local changes.

One mile southeast of the above exposure, and on the same creek, marble again outcrops on the *Polk Patterson property*. It, here, underlies, for nearly a quarter of a mile, the narrow valley at the western base of High Top mountain, and is one of the most extensive surface exposures in Fannin county. In the upper, contracted portion of the valley, covered with a virgin forest, the marble appears on the surface, on both sides of the creek, forming considerable ledges; but, lower down the valley, where the land is under cultivation,

[1] See figure 1.

it is found, only by sinking pits from eight to ten feet beneath the surface of the alluvial soil. The angle of the dip and the width of the exposure at this point indicate that the deposit must be at least eighty feet thick, and that it is evidently a continuation of the marble outcropping on lot 45, mentioned above. A limited amount of work has been carried on here, to ascertain the extent and character of the stone, and, also, to secure specimens for exhibition. These specimens have always attracted the attention of men interested in marbles. A large slab of this stone, which was sent to the Piedmont Exposition at Atlanta in 1887, was said to have been an object of general comment. Light or dark gray, more or less banded with black, are the prevailing shades; but marble of a flesh color, tinged with green, and resembling very closely the Etowah marble, occurs. The crystalline grains are small, of a uniform size, and firmly united, which makes the stone susceptible of a high polish. In the light colored variety, chalcopyrite, in small crystals, and a few scales of mica are found; but neither, probably, exists in sufficient abundance to seriously injure it for architectural purposes. The exposed surfaces of the stone generally show a uniform mode of weathering; and, wherever the outcroppings were examined, they indicated that the deposit is comparatively free from seams and cutters; however, its general soundness cannot be determined definitely, until further prospecting has been done.

ON J. M. GARRISON'S PROPERTY (*lot 79, 8th district, 1st section*), one and a half miles southwest of the Patterson property, marble is found near Cutcane creek, a small stream flowing parallel with, but in opposite direction to that of, Hame String creek. The marble located here is near the center of a narrow hollow, between two rather steep hills, and was accidentally discovered by a boy, while engaged in digging a pit. It lies beneath about five feet of earth, which appears to have been washed from the hillside above. At the time of our visit, only one excavation had been made, at which the marble could be examined. The color and general appearance of the stone are very similar to the marbles previously examined along this line of outcropping, differing only in being somewhat of a coarser texture. Nothing definite, concerning the extent and soundness of the stone, could be ascertained from the limited exposure. Small pieces of

talc are of common occurrence in the soil overlying the marble; but it is not known, whether its original source is the marble or the associated gneisses and slates.

IN THE IMMEDIATE VICINITY OF CUTCANE POST-OFFICE, *on lot* 112, *8th district*, 1*st section*, *owned by J. L. Gray*, marble occurs in the creek bottoms, overlaid, from four to five feet, by alluvial soil. It has been used to a limited extent in making lime for local consumption; but no regular quarrying has been attempted. A diamond-drill hole has been put down here in the marble to the depth of several feet; but it was impossible to secure any reliable information, as to the character of the stone penetrated.

Much of the prospecting in North Georgia has been done by speculators, who, unfortunately for the public, have kept the results of their work a secret, and, consequently, a great deal of the information concerning the marble deposits, which would otherwise be very valuable, is, at present, not obtainable for publication.

The area, over which the marble has been found on this property, is quite limited, having been discovered, so far, at only two or three places. By thoroughly prospecting the creek bottoms, it is likely that it will be found to be more extensive. The specimens of the stone collected are uniformly of a white or light-gray color, with an unusually fine texture. Mica is more or less prominent, as an inclusion, in this marble, and causes a cleavage-like structure, when abundant along certain lines. As the stone is neither exposed on the surface, nor used for building purposes, nothing is known of its mode of weathering.

TWO MILES FURTHER DOWN CUTCANE CREEK, *on the Widow Dean's property* (*lot* 145, *8th district*, 1*st section*), marble again occurs in the creek bottom. It may be seen here in a ditch, which has recently been cut just below the mill. It is said to have been discovered at other places along the creek, from four to five feet beneath the surface. It has been used to some extent in making lime. The texture and color of the marble are very similar to that found on lot 112; but there seems to be in it more mica, which, in places, renders the stone somewhat slaty in structure. Whether this mineral extends throughout the entire deposit, or is confined to certain layers, could not be determined from the extent of the exposure.

PLATE III

Perserverance Marble Works, near Jasper, Pickens County, Georgia.

NEAR THE JUNCTION OF CUTCANE AND HEMPTOWN CREEKS, on what is known as the *Park property* (*lot* 198, *8th district, 2nd section*), considerable work has recently been done, in prospecting for marble. A quarry was opened here, and many cubic yards of stone were removed; but the work was finally abandoned, before any marble was put on the market. The texture of the stone, which occurs here, is well suited for ornamental purposes; but, on account of its unsound condition, it is a question whether or not it can be quarried with profit. White and light-gray, with an occasional band of black, are the prevailing colors. Mica and tremolite are the accessory minerals, the latter forming long masses of light-colored crystals, which are quite conspicuous on the weathered surface, and which make it difficult to polish the marble. Here, as elsewhere along the creek, the marble is found beneath an overburden of earth, from four to six feet in thickness, which appears to have been deposited by the creek, as its lower layers are composed mainly of water-worn pebbles. At a number of places in the creek bottom near the quarry, it is said that marble has been discovered; but the quality of the stone at these places has never been thoroughly tested.

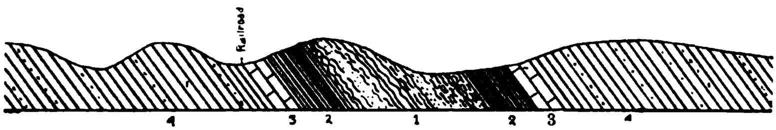
ONE MILE EAST OF MINERAL BLUFF, marble is found in a somewhat hilly section, close to the road leading to Morganton. It occurs here, about five feet below the surface, at the foot of a hill, near a small stream, where, recently, it has been extensively prospected. Two excavations, only a few yards apart, each about twenty feet square and ten feet deep, have been cut into the marble, by means of channeling machines, and many large blocks have been taken out. Some of these still remain about the excavation; but most of them have been used for making lime. The marble from one of these openings has a very fine texture and a snow-white color; but mica occurs in some of the layers, in such abundance as to cause them to split quite easily along certain lines. In the other opening, the marble seems to be sounder and of a darker color; but it all contains both mica and hornblende. The white varieties of the stone, found here, resemble very closely, in texture and color, some of the Italian marbles, and would command a high price as an ornamental stone, if they were free from mica and other impurities. The extraneous minerals in marbles are frequently quite local, and disappear some-

times in a few feet, when a stratum is being penetrated. The soundness, also, may vary greatly at different depths. It is not possible, therefore, from the data at hand, to estimate, with any degree of certainty, the value of this deposit.

ON WEAVER CREEK, one mile east of Blue Ridge, *marble occurs on the Cox property* (*lots* 239 *and* 240, 8*th district*, 2*nd section*). It outcrops, at only two or three places along the creek; but, by sinking pits, from four to five feet deep, in the creek bottom, it has been found to cover quite an area. Some test drill-holes were put down here, a short time ago by parties holding an option on the property; but the result of the work seems not to have been made public, and we were unable to secure any data, as to these tests. The texture and color of the stone are like that found near Mineral Bluff; and it has the same impurities, with the addition of chalcopyrite in the form of small crystals. This exposure is probably the southern terminus of the eastern line of outcroppings, as it has not been discovered at any place south of this point.

IN THE NEIGHBORHOOD OF SWEET GUM POST-OFFICE, the western line of marble outcroppings enters Fannin county from North Carolina. It first occurs near the State line, in a narrow valley along Rapier Mill creek, *on lot* 7, 8*th district*, 1*st section*, where it has been found in a limited area, from six to twelve feet below the surface. Only two or three pits, exposing the marble, have been made here; but, just across the state line near Culberson, N. C., an extensive quarry is in operation. A great amount of valuable stone has been taken from this quarry, and shipped to various eastern and western cities, where it always commands a high price, because of its superior qualities. The marble at both of these places is similar in color and texture. The crystalline grains, of which the stone is composed, are small and firmly united, forming a dense, compact marble, that admits of a brilliant polish. The common color is a dark-gray; but black and light-gray, streaked with black bands, occur. At the Culberson quarry is also found a flesh-colored marble, which has not been discovered on lot No. 7. Mica and other impurities are less abundant here, than at other places, hitherto examined in Fannin county; yet seams and cutters, though not numerous, cause considerable waste.

FIG. 2.



A northwest and southeast section, two miles in length, intersecting the railroad one mile south of Mineral Bluff. 1. Mica-schist. 2. Hydro-mica slate. 3. Marble. 4. Slate and gneiss interstratified with conglomerate and quartzite.

The rocks, associated with the marbles, along the western line of outcroppings[1] are like those along the eastern line; however, they are in a reversed order, the greenish hydro-mica slates lying to the east of the marbles, which overlie the gneisses and slates containing thin layers of metamorphic sandstone. The dip is generally to the southeast, at a high angle; and, at places, the strata is much folded and contorted.

AT ARP'S SPRING, one mile southwest of Sweet Gum post-office, *on lot* 42, *8th district*, *1st section*, marble appears a second time, in the Rapier Mill Creek valley. It occurs in a depression about the spring, underlying an area of about one-half of an acre. Before the adjacent hills were cleared, the marble was exposed on the surface; but now it is covered, from one to four feet deep, by sandy clays and gravels, washed in from the surrounding cultivated fields. A drill-hole was put down at this place a short time ago, to the depth of thirty feet, without passing through the stratum. The core taken out was said to have been generally sound, and free from impurities. In texture and color, the stone differs but little from that found on lot No. 7.

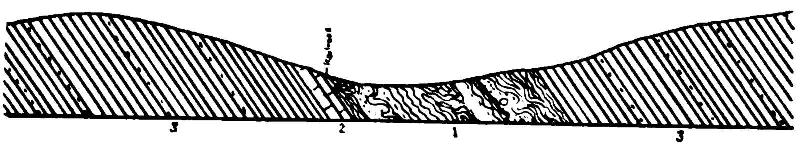
ON YOUNG STONE CREEK, near Cole's crossing, marble similar to that found on the *Arp property*, is said to have been recently discovered.

THE DICKEY PROPERTY.—While the workmen were engaged, a few years ago, in making the excavation for the bridge piers of the Marietta and North Georgia Railroad at Toccoa river, marble was discovered near the water-level. Since then, a large pit, about thirty feet square and fifteen feet deep, has been dug, just below the bridge, in order to expose the marble. As the bottom of the pit lies below the surface of the river, and is usually covered with water, it was found to be impracticable, at the time of our visit, to make an examination

[1] See figure 2.

of the stone *in situ*. It was learned, however, that the marble at the bottom of the opening was not a continuous mass, but appeared to be in large bowlders. On the opposite side of the river, the marble is said to have been found, underlying a considerable area, about the mouth of Young Stone creek; but no attempt has been made to develop it. The specimens of the stone, which were examined at the bridge, contained numerous cutters and seams, and were generally unsound. However, a very imperfect idea of a deposit, as a whole, can be obtained from a few bowlders. All the marble found at this place is of a light color and a rather fine texture, and has comparatively few impurities.

FIG. 8.



A section, two miles in length, passing northwest and southeast through the poorhouse farm, one mile south of Blue Ridge. 1. Mica-schist. 2. Marble. 3. Slate and Mica-schist with quartzite in thin layers.

ONE MILE SOUTHWEST OF BLUE RIDGE, on a farm belonging to the *County Poorhouse*, marble outcrops within a short distance of the Marietta and North Georgia Railroad.[1] There occur here, along a small stream, two exposures only a short distance apart, neither of which has been worked. The surfaces of the stone, which have been exposed to atmospheric agencies, are weathered uniformly, and appear to be generally sound. The marble is a dark-gray and of a coarse texture, with less mica, than is usually found in the marbles of Fannin county.

FACILITIES FOR TRANSPORTATION.—By examining the accompanying general map of the marble belt, it will be seen, that the marbles of Fannin county are found along the line of the Marietta and North Georgia Railroad, which follows for twelve miles the western line of outcroppings, at no place leaving them, more than a few hundred yards. The eastern line of outcroppings, though not so favorably located, could be easily reached by running a branch road from Mineral Bluff.

[1] See Figure 8.

WATER-POWER.—The map also shows that all the marble, thus far located, with only one exception, is near creeks, whose sources are well up in the adjacent hills and mountains. These streams, though usually small, are quite rapid, and have a great deal of fall, which can be utilized in furnishing water-power to operate mills or other machinery.

ALL THE OUTCROPPINGS BELONG TO THE SAME STRATUM.—The relative positions of the associated rocks, along each line of outcropping, show that all the marble belongs to the same stratum. This stratum, once horizontal, but now dipping at a high angle to the southeast along both lines of outcropping, has been brought to its present position by the folding of the strata. Erosion has decapitated these folds, and left the upturned edges of the marble extending across the country, in two continuous lines. Owing to the great depth of residual clays, and, probably, to local faults in this region, the marble is found only in certain favorable locations, usually along streams, where it has been exposed to view by the action of running water.

CHAPTER IV.

THE MARBLES OF GILMER COUNTY.

Gilmer county, though containing extensive beds of marble, has not yet produced any stone of consequence, either for building or for ornamental purposes. At a few places, the stone has been used to a limited extent, for making lime; but at present, no quarries of any kind are in operation. The prospecting, carried on in the county, has been confined to a few small pits and drill-holes, which are not sufficiently extensive, to give any very definite knowledge of the deposit.

ON ROCK CREEK, one mile southwest of Cherry Log post-office marble occurs on *J. L. Lacey's property* (*lot* 182, *8th district, 2nd section*). It outcrops in the bed of the creek, and is found a few feet below the surface in the adjacent bottoms. The area, over which the marble has been discovered, is less than an acre in extent, being confined to the narrow valley along the creek. One or two pits have been sunk on this property; but no attempt has been made, by boring or otherwise, to ascertain the thickness or the general soundness of the stone. A few drill-holes, put down here at the proper place, would probably reveal the true value of the deposit, without any great outlay of money. Wherever it was practicable to make an examination of the stone, it was found to be of the usual light or dark-gray color, and of fine texture. The weathered surfaces show but little mica or other impurities. The associated rocks are very similar to those found in Fannin county, though much more folded and contorted. If this deposit should prove to be valuable, after being thoroughly prospected, the water-power of Rock creek and the closeness of the railroad are advantages, that would materially aid in the cheap production of marble at this place.

NEAR WHITE PATH, marble is found on *lots* 272 *and* 273, 10*th district, 2nd section, owned by P. B. Whitaker.* It outcrops along White Path creek, below the railroad trestle, and lies just beneath the surface, on both sides of the railroad, underlying an area, probably of

three acres. Two or three drill-holes, from ten to thirty feet in depth, together with a ditch, exposing the stone to the distance of forty feet, is all the work, that has been done here towards developing the property. The cores, taken from the borings, are said to have been generally sound throughout their entire length; however, the stone, which was examined in the creek, was somewhat laminated, due to the considerable quantity of mica it contained. The color and texture of the marble west of the railroad is like that found on the Lacey property, while some of the layers on the east side are quite black, and, on account of their fine grain and banded structure, are likely to be taken for slate. The black variety contains small crystals of pyrite (an iron sulphide). Nevertheless, it could probably be used for tiling and other indoor work.

ON THE HOLT FARM, which joins the Whitaker property, marble outcrops at various places, about the junction of Big and Little Turniptown creeks. Here, the narrow valleys along the creeks become suddenly expanded into a wide fertile bottom, nearly surrounded by high hills. Near the center of the bottom, the marble outcrops in the creek at several places, and is said to be found underlying a number of acres in the immediate vicinity. A small amount of stone has been quarried here to make lime, and at one place a corner-stone was secured for the school building at Ellijay; but, otherwise, the deposit is undeveloped.

The general appearance of the stone is similar to the lighter varieties, found on the adjoining property, though a pale-blue variety also occurs. The crystalline grains are quite small, being difficult to distinguish with the unaided eye. The surfaces of the outcropping at some places are unevenly weathered, and show a somewhat laminated structure, while at other places they weather evenly, and appear to be comparatively free from impurities. The area, over which the marble has been located at this place, indicates a rather extensive deposit; and it, very likely, contains much valuable stone. This, however, cannot be positively ascertained, until the property is thoroughly prospected.

Big Turniptown creek is a stream of considerable size, and would furnish quite a water-power, that could easily be utilized, in operating quarries on the Holt property.

FIVE MILES SOUTH OF ELLIJAY, near the head-waters of Tolona creek, marble occurs on *John Ray's property* (*lot* 225, 10*th district, 2nd section*). This is the northern terminus of a series of outcroppings, which extend along this creek, with only one or two interruptions, for about six miles. The marble appears at this place, at the foot of a hill and in the branch near by. At no place has any work been done to test its extent or quality. The specimens collected are fine-grained, and of a light-gray or white color.

A FEW HUNDRED YARDS SOUTH of this exposure (*on lot* 260, 10*th district, 2nd section*), there is a more extensive outcropping, which forms, near the creek, a bluff about twelve feet in height. A small quarry was opened, here, some years ago, to secure stone for making lime; but it has since been abandoned. Much of the marble, outcropping here, seems to be quite solid, free from mica, and weathered evenly on exposed surfaces. It is similar, both in color and texture, to the stone found on lot 225, described above. Just west of the marble at this place, is quite a deposit of iron ore, which is frequently found associated with the marbles of North Georgia. It reaches its greatest development on the Holt property, where it appears quite abundant on Iron Knob.

ONE AND A HALF MILES SOUTH OF TOLONA POST-OFFICE, on *lots* 142 *and* 143, 12*th district, 2nd section*, marble outcrops along the eastern side of the valley, forming a line of cliffs as far south as Price's creek. The marble, here, is mostly light-colored and fine-grained; but there also occurs a dark or motley-colored variety, with coarse grains. Both of these varieties contain more or less mica; especially is this true of the fine-grained variety. Quartz is sometimes seen to project from the weathered surfaces, in the form either of veins or of nodules. The marble, that has been exposed in the cliffs for a long time, commonly shows a comparatively even weathering. Near the railroad trestle, on lot 142, a drill-hole was put down, about two years ago, by a party holding an option on the property, to the depth of eighty feet, without passing through the marble. The result of this work was kept a secret, and, as a consequence, no reliable information could be obtained, with reference to the character of the stone penetrated. The value of the marble in this vicinity depends largely on its soundness, and any light on this

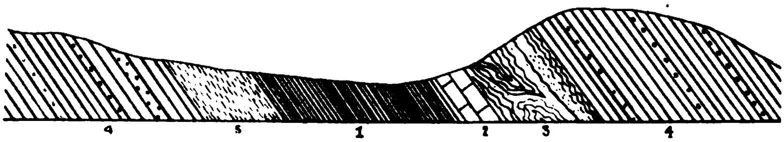
PLATE IV.

SOUTHERN MARBLE COMPANY'S MILL, MARBLE YARD AND QUARRY, NO. 1, NEAR MARBLE HILL, PICKENS COUNTY, GEORGIA.

important question, that is likely to be obtained from deep boring, is very desirable, and should always be carefully noted.

HENRY GARTRELL'S PROPERTY, generally known as *Marble Bluff*, joins lot 142, above mentioned, and lies along the east side of Tolona valley, just below the mouth of Price's creek. The marble forms near the creek a bluff, eighty feet in height, almost perpendicular, with the Marietta and North Georgia Railroad running at its base.

FIG. 4.



A northwest and southeast section passing through Marble Bluff near Henry Gartrell's residence. 1. Light-green slates. 2. Marble. 3. Mica-schist. 4. Mica-schist and gneiss with thin layers of conglomerate. 5. Black slate.

This is one of the most extensive natural exposures of marble in the State, and has always attracted attention; but, so far, it is practically undeveloped. The marble attains a thickness, at this place, of about one hundred and seventy-five feet, and varies greatly, both in texture and color. There are three principal colors, viz:—pink, white and dark-gray. The pink is found near the upper part of the stratum, where it forms thin layers, which appear to extend only a short distance along the edge of the outcropping. The white is the most abundant; it, also, is found in the upper part of the stratum, while the darker colored, or gray, lies at the base. The last named variety has rather a coarse texture, being made up of crystalline grains frequently an eighth of an inch in diameter, yet so firmly united as to form a very solid marble. The white and the pink have a very fine texture; and, when free from mica, they admit of a very high polish. These fine-grained marbles, when they contain much mica, weather unevenly; but, where this impurity is absent, the weathered surface is found to be quite smooth, and the stone, well suited for ornamental purposes. The darker varieties have but few impurities, and, consequently, weather evenly. The lower layers of the stratum seem to be generally sound, and free from seams, while the upper layers are more or less laminated, and, at places, show evidence of shearing.

Some chalcopyrite and quartz occur, as inclusions in the marble; but they are not in sufficient quantities to be injurious. A company began work here, last spring, with a view of opening a quarry; but, at the time of our visit, the work was temporarily suspended. No work had previously been done here, except the digging of one or two pits in the creek bottom, to ascertain the extent of the marble. This property is the most favorably located of any in Gilmer county, for the cheap production of marble. Besides the railroad and suitable grounds for the location of mills and marble-yards, Price's creek, a mountain stream of considerable volume of water, can be easily controlled, so as to furnish the necessary power to run all the machinery. For the first two miles, above where it enters Tolona valley, it has a fall of nearly one hundred and fifty feet, and the narrow valley or gorge, through which it flows, becomes so contracted at places, that retaining dams can be constructed, with but little expense.

CHAPTER V.

THE MARBLES OF PICKENS COUNTY.

Pickens county is, at present, really the only marble-producing county in the State. The value of the deposits, here, has long been known; but only of recent years have they been worked on an extensive scale. A number of companies are now operating in the vicinity of Tate, each of which makes annually large shipments of stone, for both building and ornamental purposes.

The marbles enter this county from Gilmer, on *lot* 140, *5th district, 2nd section,* which joins the Gartrell property. The bluffs, here, are almost as high and precipitous as those on the adjoining lot; and the only apparent difference in the character of the stone is the absence of the flesh-colored layers. A few hundred yards further down the creek, on *lot* 139, *5th district, 2nd section,* a considerable quantity of marble has been quarried, for making lime. The kiln is situated on the east side of the railroad, where a siding has been put in, from the main track. The capacity of the kiln is about one thousand barrels per month, selling at seventy-five cents per barrel. It is used for both mechanical and agricultural purposes. The lower layers of the stone on this lot appear to be quite sound, and weather evenly. On the opposite side of the railroad from the lime-kiln, a drill-hole has been put down in the marble thirty feet. The core, taken from the boring, is said to have been quite solid, throughout its entire length.

ON THE GODFREY PROPERTY (*lot* 151, *5th district, 2nd section*), near the mouth of Fisher's creek, is an extensive exposure of marble, that seems to be the southern terminus of the deposit in Tolona valley.

Between this property and the lime-kiln, lies *lot* 138, *5th district, 2nd section,* through which the marble continues, forming high bluffs, which overhang the creek; but, on the Godfrey property, it appears, as large exposed surfaces on the gradually sloping, wooded hillside. It also outcrops in a number of places in the cultivated

fields. A small quarry, long since abandoned, was opened here, more than forty years ago, in order to secure marble for tombstones. These stones are now to be found throughout the county, in various graveyards, little affected by the atmospheric agencies, after an exposure of thirty or forty years. Refuse blocks and spalls lying about the quarry, and the old marble chimney at the Godfrey residence, well illustrate the durability of this stone. Its color is usually white or dark-gray. The texture varies from coarse to fine-grained; the former, which predominates, is sounder than the latter, and contains scarcely any mica.

About half a mile south of this exposure, and running parallel with it, is another line of marble outcroppings, which belong to an entirely different stratum. It is an impure dark-colored stone, with a somewhat slaty cleavage, forming, on the hill near Fisher's creek, a bluff thirty or forty feet in height. What appears to be the same stratum outcrops in the road opposite Tolona school-house, and is found near the State line in Fannin county; but only in the vicinity of Ball Ground and Canton, in Cherokee county, is it likely to be of any economic value.

Four miles northeast of Talking Rock Station, on the head-waters of Fisher's creek, several hundred dollars were spent, a few years ago, in prospecting for marble on the *Eager property;* but the work was finally abandoned without opening any quarry. Three excavations were made here—two on the hillside, and one near the head of a narrow hollow close by. The marble appears as a natural exposure, at several places on the hill; but it lies beneath the surface in the hollow. The prospecting, carried on here, was directed mainly to stripping the earth from the marble, with a view to determining the extent and character of the deposit. Some of the surfaces, thus exposed, show a very peculiar mode of weathering. At one place a large cavity, which resembles very closely a pot-hole, may be seen. It is about eight feet in diameter and fifteen feet deep. This irregular mode of weathering is due, either to the unsound condition of the stone or to the impurities which it contains, or to both of these causes combined. The crystalline grains, making up the stone, are sometimes an eighth of an inch in diameter; but they are usually much smaller. The coarse-grained variety is gen-

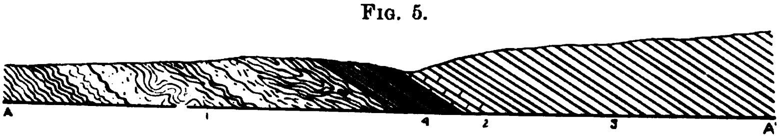
erally found in the lower part of the stratum, while the fine-grained and lighter-colored variety occurs above.

This property is the most unfavorably located, with reference to transportation, of any heretofore examined; however, a branch road not over five miles in length could be easily constructed up Fisher's creek, connecting with the main line of the Marietta and North Georgia Railroad.

TWO MILES EAST OF JASPER, on Longswamp creek, marble occurs on *J. P. Harrison's property*, on which are the Perseverance Marble Quarries. It forms here, along the east side of the creek, an almost continuous series of bluffs, forty or fifty feet in height and nearly a mile in length. Four quarries have been opened, one of which was quite extensively worked a few years ago, and produced much valuable marble. But it is at present abandoned, and the greater part of the machinery has been removed to the Piedmont works, where better facilities for transportation are at hand.

The stone found here is mostly of a snow-white color, having a fine texture; but, unfortunately, seams are of such frequent occurrence, as to make it difficult to quarry blocks of large size. The manner, in which the marble weathers, is well illustrated by a number of tombstones from this quarry, which have been exposed for several years in the graveyard near Jasper. Some of these stones are uniformly weathered, while others, containing mica, have rough and irregular surfaces. The fine texture and brilliant polish, which this stone admits of, makes it very valuable for ornamental purposes. Two diamond-drill holes, one 111 feet and the other 130 feet deep, have been put down on this property, neither of them passing through the stratum of marble. The parts of the cores from these holes, which were examined, showed the character of the stone penetrated, to be similar to that exposed in the natural outcroppings.

FIG. 5.

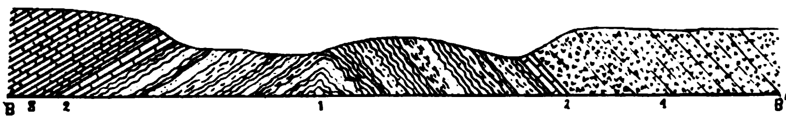


A section, 1½ miles long, passing through Perseverance quarry along the line A–A′. (See detail map of Tate and vicinity.) 1. Mica-schist. 2. Marble. 3. Gneiss and Mica-schist. 4. Mica-schist and slate.

The marble here dips to the southwest at an angle of about 30°, and attains a thickness, as demonstrated by the boring, of nearly two hundred feet. Longswamp creek divides on this property into two streams of nearly the same size. Each branch is quite rapid, and has a great deal of fall, that could be easily utilized, by constructing dams at the narrow points in the valley. A water-power, sufficient to operate an extensive quarrying-plant, could be secured here, with a comparatively small outlay of money.

SOUTH OF THE HARRISON PROPERTY the marble continues along the east side of the creek for about two miles, being seen last near Tate's mill. At some places, it appears as bluffs, well up on the hill-side; but, in others, it is found underlying the creek bottom. Some prospecting has been done at two places along the bluff, where the color and texture of the stone resemble very closely that found further up the creek.

FIG. 6.



A section, 1½ miles in length, along the line B–B′ (See detail map of Tate and vicinity.) 1. Mica-schist and slate. 2. Marble. 3. Garnetiferous gneiss. 4. Hornblende.

ONE MILE EAST OF MARBLE HILL POST-OFFICE, on *the Disheroom property*, marble occurs on both sides of the east branch of Longswamp creek, where it forms two different lines of outcroppings. The outcropping lying farthest to the north continues along the creek for only about half a mile, where it seems to be abruptly terminated by a fault, while the other forms a continuous series of outcroppings more than five miles in length. It first runs almost due east and west for about three miles; but, at the juncture of the east and west branches of Longswamp creek, it turns rather abruptly to the south, and follows the east side of the main stream for nearly two and a half miles, where it finally disappears beneath the overlying gneiss. There are only two natural exposures of the marble on the Disheroom property, and these are so limited in extent, as to give but a very imperfect idea of the general character of the stone.

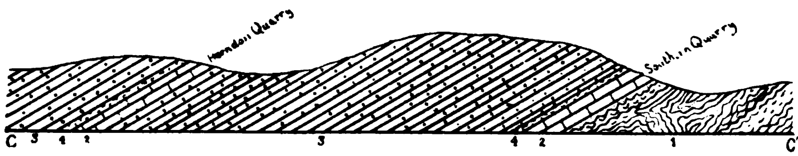
PLATE V.

Southern Marble Company's Quarry No. 4, Marble Hill, Pickens County, Georgia.

The specimens secured from the southern line of outcroppings are of a white or light-gray color, and contain a good deal of chalcopyrite. The texture is much finer, than that of the white variety of marble found on the small line of outcroppings elsewhere in this vicinity. Specimens from the opposite side of the creek, and belonging to a different line of exposures, are of a flesh color, more or less banded with black and green. On the adjoining lot, owned by William Pool, the marble appears to be much more extensive. It is said to be found here, at a number of places in the creek bottom. It outcrops in the spring, near the house, and is exposed south of the road in a small stream, where it has been prospected. The stone is very similar to that found at the Southern marble quarries, situated on the same outcroppings, a few hundred yards farther down the creek.

THE SOUTHERN MARBLE QUARRIES are located in the immediate vicinity of Marble Hill Post-office, four miles east of Tate, where a branch road from the quarries connects with the main line of the Marietta and North Georgia Railroad. The valley of the east branch of Longswamp creek at this point becomes quite narrow ; the adjacent hills are high and precipitous, especially those south of the creek, where the marble forms numerous bluffs. Four large quarries have been opened here, each of which has been extensively worked. The one farthest up the creek is situated on the hillside, about one hundred and forty feet above the valley, and is connected with the mill by an incline railway nearly one hundred yards in length.[1] An excavation eighty feet square and thirty feet deep has been made in the upper part of the stratum, from which a great deal of stone has been taken.

FIG. 7.



A section, 2½ miles long, passing through the Southern and the Herndon quarries, along the line, C–C′. (See detail map of Tate and vicinity.) 1. Mica-schist and slate. 2. Marble. 3. Garnetiferous Gneiss. 4. Hornblende.

[1] See plate IV.

Just above the marble at this point, and in contact with it, is a fifteen or twenty foot vein of dark, massive rock, apparently made up entirely of hornblende. The change, which has noticeably taken place in the overlying garnetiferous gneiss, indicates that this is an intrusive vein, that is, that at one time a hot plastic mass was forced between these two strata. As a result of contact with such a hot body, the rock above and adjacent, once a mica-schist, is now garnetiferous gneiss. The marble beneath has partly recrystallized, and is now strikingly free from carbonaceous material, which gives to the Georgia marbles their black or blue color.

Other quarries in the neighborhood show exactly the same conditions. The fountain-head of all these intrusive veins (apophyses) appears to be a high hill a short distance to the northeast. This seems to be a solid mass of the same matter, which characterizes the apophyses. Aside from its economic importance, in producing a white variety of marble, it is geologically interesting, as an excellent example of contact metamorphism.

The stone quarried here is very solid, rarely showing any seams or lines of stratification; and, as a consequence, blocks can be secured of almost any size. The surfaces of the best varieties of the stone, exposed in natural outcrops for long periods of time, always show a remarkably uniform mode of weathering. The crystalline grains, making up the stone, are usually large and semi-transparent; some are fully a quarter of an inch in diameter, and when polished give to the surface of the marble a somewhat motley appearance, rather than the uniform white.

There are a number of accessory minerals found in the marble, the most common and injurious being mica. It sometimes occurs along definite lines in such quantity, as to seriously interfere with the process of polishing, and causes the stone to weather unevenly. Tremolite and diopside (?) also occur as inclusions. The former is white, or grayish-white; the latter, a light-green. They appear as blades, crystals and crystalline masses, penetrating the stone, and can be readily recognized by their glistening luster and splintery fracture. These minerals, being about twice as hard as marble, cause exposed surfaces to weather very irregularly, and interfere with polishing.

Piedmont Marble Works, near Marble Hill, Pickens County, Georgia.

The marble attains, at this place, a thickness of nearly two hundred feet, and dips to the south at an angle of about 20°.

A short distance farther down the creek, on the same hillside, but nearer the valley, are located two other large excavations, each about the same size as the one above described, which produce a very similar marble, though not of such uniform white color.

The fourth quarry, which was the only one being worked at the time of our visit, is still farther down the creek, and well up on the hillside, in the upper portion of the stratum. The marble quarried here appears to have less mica and other impurities, than that from the other quarries, yet it retains about the same texture and color.

The mill is located in the valley near the quarries, and is connected with them by an incline railway, which is so graded that the cars, when loaded with marble, run by reason of their own weight directly to the mill.[1] The motive power in use is water. It is collected from a number of small streams in the mountain about two miles away, and is conveyed through ditches and pipes to the mill. Here, with a two hundred and ten foot head, it is conducted through a two-inch nozzle on to a Pelton wheel, which generates sufficient power to run all the necessary machinery connected with the mill. The amount of money annually saved to the company by the utilization of this water-power must be considerable; and it is a practical illustration of what might be done, with a comparatively small outlay of money, in numerous other places along the marble belt in North Georgia. On account of its white color and superior finish, the marble from these quarries is much sought after, for furniture, monuments and interior decoration. The stairsteps and the main part of the tiling in the State capitol are from quarry No. 1; they well illustrate the general run of the stone.

The number of hands employed at these works varies according to the demand for the stone. At the time of our visit, only about thirty were regularly engaged.

THE KENNESAW QUARRIES are located three-quarters of a mile below the Southern, near the creek. They employ about the same number of hands. Two excavations, close to each other, have been made at this place; one is seventy-two by ninety feet at the top, and

[1] See plate V.

has been gradually increased in size, by tunneling to the depth of eighty feet; while the other, which has been only recently opened, is one hundred and ten by ninety feet at the surface.

The stone is snow-white, with an occasional irregular blotch of black or dark-gray. In structure, it resembles very closely the marble from the Southern quarries, being generally sound and free from impurities. These quarries, owned and operated by the Georgia Marble Company, produce annually large quantities of stone used for monuments, furniture, interior decoration etc.

THE PIEDMONT QUARRIES are only about two hundred feet west of the Kennesaw quarries, and on the same portion of the stratum. The amount of marble found here is practically inexhaustible. It outcrops at various places along the north hillside, dipping 25° S., 10° E., and underlies a great part of Longswamp valley, which at this point is nearly half a mile in width.

The thickness of the deposit, though difficult to determine with any degree of accuracy, must be fully two hundred feet. The color and texture of the stone is practically the same as that of the Kennesaw marble. Seams frequently occur in the stone and cause considerable waste; otherwise it is comparatively free from defects. The mill for sawing and polishing the marble is near the quarry, and is one of the best equipped mills in North Georgia. It has nine gangs of saws and two large rubbing-beds, run by a two hundred and fifty horse-power engine. The plant is also supplied with an electric-light system, enabling the works to be operated both day and night, which is sometimes necessary in order to supply the demands for the stone. Chilled iron globules with sand are used in sawing the marble. The rate, at which the saws cut by this process, is said to be about one third faster, than when sand alone is used.

The whole number of hands, including stone-cutters employed at these works, when visited, was between forty and fifty; but it has since been learned that the force has been greatly increased to fill some extensive contracts, which the company has secured. With the improved machinery, which these quarries now possess, they are able to produce annually a great amount of stone, which is used for both building and monumental purposes.

THE HERNDON PROPERTY, owned by *James P. Harrison and*

PLATE VII.

ETOWAH QUARRY, GEORGIA MARBLE WORKS, NEAR TATE, PICKENS COUNTY, GEORGIA.

others, is located two miles south of the Piedmont quarries. The marble occurs here in a narrow valley, drained by a small stream flowing into Longswamp creek. It is naturally exposed at only one or two places in the branch; but, by sinking pits, from two to six feet beneath the surface, it is found to underlie more than an acre. At one place a quarry has been opened, and some large blocks have been taken out, which show the stone to be of a very fine quality. In texture and color, it is much like the marble at the upper quarry of the Southern works, though the accessory minerals, especially mica, are not so abundant. The dip, which is 12° S. E., indicates only a comparatively slight change from the original horizontal position of the marble. On this account, the stone on this property will probably be found to be generally sound. Nearly half a mile below this opening, where the valley becomes contracted into a narrow gorge, marble again outcrops at several places on the steep hillside. A few narrow bands of flesh-colored marble were observed here; but, otherwise, it was similiar to that found farther up the branch.

The expense of transportation has, so far, seriously interfered with the development of the Herndon property. A branch railroad is now under construction, connecting it with the Piedmont quarries. When completed, it is the object of the company to begin work on an extensive scale. The same dark, coarse, crystalline hornblende, that is found associated with white marble at other places in the neighborhood, also occurs here.

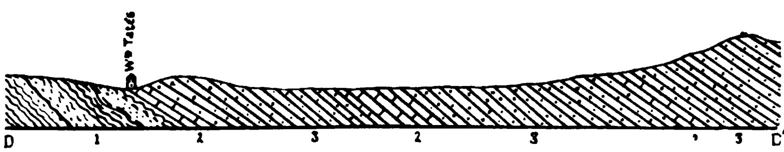
THE GRIFFIN PROPERTY, which is, at present, *controlled by the Georgia Marble Company*, lies immediately west of the Piedmont quarries, on the same line of outcropping. The marble is exposed at a number of places along the hillside, and it also underlies the creek bottom. That, which occurs along the creek, appears to be the lower part of the stratum, and is, at places, of a flesh color, while that on the hillside is white, with blotches of dark-gray. This line of exposures continues, with few interruptions, along the east side of Longswamp creek for about two and a half miles. At a number of places on this line of outcroppings, a limited amount of prospecting has been done; but no regular quarrying has been attempted. The dip, as determined at several points, is from 20° to 30° southeast.

TWO MILES NORTHWEST OF THE PIEDMONT WORKS, and on the

opposite side of a high ridge, marble occurs on *S. A. Darnell's property.* This is an entirely different line of outcropping from the one above described, though the structure of the marble and the character of the associated rock, both show, that it belongs to the same stratum. For nearly two miles, these two lines of exposures run almost parallel with each other; but they seem to finally unite, just before disappearing beneath the gneisses in the lower end of Tate's bottom. The marble is found on this property, outcropping on the hillside, and also in the creek bottom, near the juncture of the two branches of Longswamp creek. It has a somewhat finer texture, than that found at the other exposures in the vicinity; yet, in color and structure, it remains about the same. The dip, though difficult to determine, on account of the limited exposure, appears to be about 20°, almost due east. Very little prospecting has been done here; but, just across the creek, on the adjoining lot owned by Dr. Tate, a number of drill-holes have been put down to the depth of eighty or ninety feet. The cores from these borings are said to show the marble to be generally sound, with a texture and color much like the Creole from the Georgia works.

A FEW HUNDRED YARDS WEST OF THIS PROPERTY, and separated from it by a narrow ridge, is a third line of outcropping. It appears first on *lot* 82, *4th district, 2nd section,* and continues parallel with the other two lines of exposures, for about one and a half miles, finally disappearing on a hillside near William Tate's residence.[1] Along this line of exposure, some prospecting has been done by boring and sinking pits. This marble does not seem to form such a thick stratum, as at the other exposures farther west; but the dip and general appearance of the stone remain unchanged.

FIG. 8.



A section, 2½ miles long, passing, near William Tate's residence, along the line D–D'. (See detail map of Tate and vicinity.) 1. Mica-schist and slate. 2. Marble. 3. Garnetiferous gneiss.

[1] See detail map and figure 8.

THE QUARRIES OF THE GEORGIA MARBLE COMPANY are located in the valley of Longswamp creek, one and a half miles east of Tate Station. The valley here is nearly half a mile in width, the greater part of which is underlaid with marble, from six to eight feet beneath the soil. The unusual width of the deposit at this place is due to a fold in the stratum. In making an excavation for the smoke-stack of the company's mills, a few years ago, it was found that the marble at that point dipped in opposite directions, which locates the center of the fold, whose upper portion has been removed by erosion.[1] The Creole and Cherokee quarries are located on the east side of the fold, while the Etowah is on the west side.

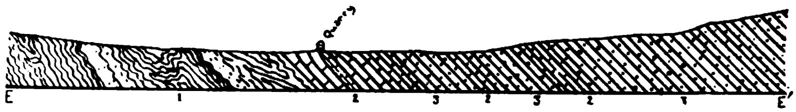
There are two of the *Creole quarries* within a few feet of each other, designated respectively as Creole No. 1 and No. 2. The former, which was the first opened, is eighty by eighty-five feet at the surface, and gradually increases, by tunneling, to the depth of one hundred and thirty feet, where it is one hundred and ten by one hundred and fifteen feet. The latter is eighty by ninety feet at the surface, and only ninety feet deep. The marble from these quarries is quite free from impurities and seams, and even the original lines of bedding have been entirely obliterated by metamorphism, so that blocks of almost any size can be secured. The texture is quite coarse, and the color is white, clouded or banded with black or bluish-gray, affording striking contrast. The dark color is due principally to graphite in the form of small foliaceous scales in clusters, evenly distributed through the large, nearly transparent grains of calcite.[2] This stone, on account of its pleasing mottled effect, and the brilliant polish, which it takes, has an extensive use throughout the country for monuments and interior decoration.

The Cherokee quarry, eighty by ninety feet and forty feet deep, is near the Creole quarries. The marble found here is of a more uniform white color than the Creole; but, otherwise, it is very similar.

A FEW HUNDRED YARDS EAST OF THE CHEROKEE QUARRY, and near the creek, is the *Etowah*. The marble is here overlaid by a deposit, about eight feet in thickness, which has evidently been made by the creek, as its lower layers contain many water-worn pebbles, which

[1] See figure 9.
[2] See Microphotograph 1.

FIG. 9.



A section, 1½ miles in length, passing through the Georgia Marble Co.'s quarries, along the line E–E′. (See detail map of Tate and vicinity.) 1. Mica-schist and slate. 2. Marble. 3. Garnetiferous gneiss.

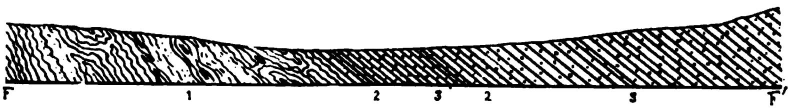
are in immediate contact with the roughened surface of the stone There are two quarries here, one of which has been extensively worked, while the other has been only recently opened. In structure and texture, the stone is much like the Creole; but it contains more impurities. It is of a pink or flesh color, and, frequently, more or less banded with dark or light shades, which give to the polished surface a very beautiful effect. The dark colors appear to be mainly caused by mica and graphite, arranged along certain lines, which probably correspond to the original lines of bedding. This peculiar flesh-color is found at a number of places along the marble belt of North Georgia; but it is always quite local. It is due to a minute quantity of very finely divided ferric oxide, disseminated throughout the mass.[1] This marble is much used for wainscoting, tiling, furniture etc.; and so popular has it become, that the company finds it difficult to supply the demand. Fine examples of it may be seen in the State capitol, where it is used for the wainscoting of the first floor. The "Creole" forms the border of the tiling in this building. The thickness of the deposit, underlying the valley in the vicinity of the Georgia Marble Company's quarries, is at least two hundred feet. Along the branch above the Creole quarries are a number of natural outcroppings, whose exposed surfaces show the mode of weathering. This is also well illustrated by the marble steps at Colonel Stephen Tate's residence, which are said to have been quarried by the Indians. These stones, although exposed under dripping-eaves, for more than forty years, show no signs of disintegration; and they still retain, in a remarkable degree of perfection, their sharp edges and corners.

A branch road, owned and operated by the Georgia Marble Company, connects the quarries with the main line of the Marietta and

[1] See chemical analysis of the Etowah marble.

North Georgia Railroad. The company's plant is supplied with the latest improved channeling and gadding machines, mills, traveling-derricks etc., all kept in an excellent state of repair by the well-equipped machine-shop near by. The mills have twenty-nine gangs of saws, and are among the largest, as well as the most completely furnished, in the country. From one hundred and fifty to two hundred hands are regularly employed at the works.

FIG. 10.



A section, 1½ miles in length, along the line F–F′. (See detail map of Tate and vicinity.) 1. Mica-schist and slate. 2. Marble. 3. Garnetiferous gneiss.

The following price-list gives a fair idea of the stock of marble, which the Georgia and other companies located in Longswamp valley now offer to the trade:—

ROUGH MARBLE IN BLOCKS—PER CUBIC FOOT.

Kennesaw	from	$1 25	to	$2 50
Etowah	"	1 25	to	3 00
Creole	"	1 00	to	2 50
Cherokee	from	1 00	to	2 50
Piedmont, select				2 50
Piedmont, average				1 75
Piedmont, building stock				1 25
Southern, No. 1				3 00
Southern, No. 2		1 00	to	2 00
Southern, No. 3		.75	to	1 00

Blocks 7 to 12 feet long, 25 to 50 cents extra, per cubic foot.

SLABS.

Full size of slabs, per superficial foot.

Southern, No. 1,	7-8 in. to 2 in.	in	thickness,	from	$ .35	to	$ .75
Southern, No. 2,	"	"	"	"	.30	"	.65
Southern, No. 3,	"	"	"	"	.25	"	.50
Piedmont, No. 1,	"	"	"	"	.37	"	.70

Piedmont, No. 2,	7-8 in. to 2 in.	in	thickness,	from	$ .28	to	$ .60
Piedmont, No. 3,	"	"	"	"	.20	"	.50
Kennesaw . . .	"	"	"	"	.25	"	.65
Cherokee. . . .	"	"	"	"	.22	"	.65
Etowah . . .	"	"	"	"	.37	"	.80

Slabs over 4 feet wide, or over 7 feet long, 10 to 25 per cent. extra.

Slabs coped to size, 10 cents per superficial foot, extra.

Boxing, 7-8 inch to 2 inches, per superficial foot	$ .05
Boxing, 2 1-2 inches per superficial foot	.10
Sand-rubbing, per superficial foot	.05

MONUMENTAL STOCK—PER CUBIC FOOT.

Piedmont, No. 1, ...	$4 00
Piedmont, No. 2, ...	3 00
Piedmont, No. 3, ...	1 50
Creole	from $2 50 to 4 50
Kennesaw	from 3 00 to 4 00
Cherokee	from 3 00 to 4 00
Etowah	from 4 00 to 5 00
Southern, No. 1, Southern, No. 2, Southern, No. 3, ...	from 2 00 to 5 00

MISCELLANEOUS.

No. 3 base strips, posts and bottom bases, per cubic foot . .	$1 50
Markers, 12 to 14 inches long by 3 inches thick	.35
Markers, 12 to 14 inches long by 4 inches thick	.50
Markers, 16 to 18 inches long by 3 inches thick	.75
Markers, 16 to 18 inches long by 4 inches thick	1 00
Foot stones, 5 to 8 inches wide by 2 inches thick	.20
Foot stones, same size, sawed heads	.22
Foot stones, same size, sawed heads and sand-rubbed	.25
Foot stones, same size, sawed heads, sand-rubbed and boxed .	.28
Diminished dies, extra per cubic foot	.50

Georgia Marble Works, near Tate, Pickens County, Georgia.

TILE—KENNESAW, ETOWAH, CREOLE AND CHEROKEE.

Per superficial foot, seven-eighths to one inch thick.

Average stock, 10 to 16 inches square	$ .25
Ashlar tile, 10x20 and 12x24 inches	.25

Selected tile, in color and quality, 5 to 10 cents extra.
Inferior tile, for cellars etc., 5 to 10 cents less.
Half and quarter tile, 33⅓ per cent. extra.
Bordering, same as tile.
Irregular and small sizes, furnished at value by agreement.
Corners taken off, 1½ cents each.
Boxing, 2 cents per foot extra.
For 1¼ inches thick, add 5 cents per foot.

At Nelson, the first station south of Tate, marble outcrops near a spring, located about two hundred yards south of the depot. The exposure is confined to a few outcroppings, whose weathered surfaces resemble, in general appearance, the light-colored and fine-grained marble found in Longswamp valley.

Some prospecting has been done here; but neither the quantity nor the quality of the stone is said to have been sufficiently promising, to justify opening a quarry.

CHAPTER VI.

THE MARBLES OF CHEROKEE COUNTY.

Cherokee county has long been known to contain more or less marble; but it has never become an active producer. The same stratum of marble, which is so well developed in Fannin, Gilmer and Pickens counties, occurs, also, in Cherokee. The exposures here, however, are not so extensive nor so continuous. They seem to be more or less disconnected, as if misplaced by faults.

In this county, the dark and rather impure marble, which was first noticed in Pickens and Gilmer counties, becomes quite well developed, and forms, at places, beds of considerable thickness. There has been a limited amount of prospecting done for marble at a number of localities in this county, though no regular quarries have been opened. The so-called green marble, which has been worked near Hollow Spring, and which attracted considerable attention a few years ago, as an ornamental stone, is serpentine; and consequently, it is not considered in this report, which treats only of the true marbles.

Four miles northeast of Ball Ground, at the bridge on the road leading to Dawsonville, the stratum of dark colored marbles first make their appearance in Cherokee county. From this point, it forms a series of outcroppings about ten miles long, extending in a southwestern direction, by way of Ball Ground, to within a short distance of Canton, where it seems gradually to thin out. At the above named bridge, it is exposed on both sides of the road west of the creek, and has been used in constructing the piers of the bridge. Some of the layers are very impure. They form micaceous sandstones, cemented with calcium carbonate, and weather into a porous sandy mass. Other layers have few impurities, are of a light-gray color, and weather more evenly. The stone found here appears to be too much laminated,

and generally contains too many impurities to be well suited, either for building or for ornamental purposes.

ON J. HALBERT'S PROPERTY, *lots 259 and 260, 4th district 2nd section,* southwest of the bridge, on the right bank of Long-swamp creek, the dark-colored marble makes its appearance a second time. It is exposed at a number of places along the creek, and in the field near the house. The stratum attains a thickness, here, of at least one hundred feet, and dips to the southeast at an angle of about 30°. At the time of our visit, no prospecting of any consequence had been done on this property, and our examination was, therefore, confined to the natural exposures. The stone in different outcroppings varies considerably, both in structure and in composition. At some places, it has a more or less slaty structure, due mainly to the abundance of mica; while, at others, it is solid, and comparatively free from mica and other impurities. The color is usually a dark-gray; but a light-gray and a black are also found. The latter seems to be well suited for tiling; but it does not weather evenly, on account of the impurities, which it contains.

ON THE OPPOSITE SIDE OF THE CREEK FROM THE HALBERT PROPERTY, a coarse-grained, white marble has been recently discovered on *lot 296, 4th district, 2nd section.* It is exposed at only one place, in a small stream near the point, where it empties into the creek. The stone found here resembles the marble in the vicinity of the Georgia Marble Quarries, and probably belongs to the same stratum. As no prospecting of any consequence has been done on the property, nothing is known of the extent of the deposit. The dark-colored marble is exposed along the road between the Halbert property and Ball Ground at a number of places. It shows up especially well at Farmer's Spring, where it is associated with a very coarse-grained gneiss. The general character of the stone found here is about the same as that at other exposures, and requires no further description.

THREE-QUARTERS OF A MILE SOUTH OF BALL GROUND, near the road leading to Canton, is an exposure of marble on Mrs. Stern's property. It occurs here at a number of places along a small branch. The exposed surfaces are usually unevenly weathered,

which is due to mica and other impurities found more or less abundant in the stone. It is of a dark-gray or black color, very fine-grained, and admits of a fair polish; but it has a somewhat laminated structure. At a number of places on the road leading to Canton, there may be seen other outcroppings, which belong to the same stratum.

NEAR MABEL STATION, six miles northeast of Canton, is quite an extensive exposure of dark-colored marble. It outcrops, here along two small streams *on property owned by G. W. Crain.* One of these streams runs at almost right angles to the strike of the marble, and exposes it for more than one hundred yards. The total thickness of the deposit, here, must be at least one hundred and twenty-five feet. At the time of our visit, J. W. Jarvis, who holds an option on the property, was having some drill-holes put down, here; but the work had not then been carried to a sufficient extent to give any definite results. The color is black or dark-gray. Sometimes, these colors alternate with each other, which gives to the stone a banded-like appearance. The impurities are chiefly mica and magnetite, with an occasional crystal of pyrite.[1] These frequently become so abundant along definite lines, as to cause a slate-like cleavage and irregular weathered surfaces. The more solid portion of the stone found here admits of a fair polish, and seems to be well suited for tiling etc.; but it usually contains too many impurities, to make it desirable for outdoor work. The last exposure examined on this line of outcropping is about two miles west of Canton, on the Chattahoochee Mining Company's property, where it has been used for making lime. It is here very much reduced in thickness, and is of no economic importance as a building-stone.

ON SHARP MOUNTAIN CREEK, two miles west of Ball Ground, is a second line of marble outcroppings, which appears to be a part of the same stratum, that has just been described. It extends in a southwesterly direction, parallel with the first line of outcropping, as far south as Hickory Log creek, where it has been prospected on *P. W. Stafford's Property.* The marble found here is much like that, in the vicinity of Ball Ground; but it is much whiter.

[1] See plate XII, Fig. 2.

THREE MILES SOUTHEAST OF BALL GROUND, marble occurs *on L. E. Cowart's property, lot* 305, *3rd district, 2nd section.* It is exposed here along a small branch near Sharp Mountain creek. In texture and color, the marble resembles very closely that, which occurs in Longswamp valley; and it probably belongs to the same stratum. It has rather a coarse grain, and a white or light-gray color, banded with black. A flesh color, much like the Etowah, also occurs ; but it does not appear to be very abundant. From the limited outcropping, it was impossible to tell anything very definite about the extent and the general soundness of this deposit ; but surface indications are favorable, and seem to warrant at least a limited outlay of money in prospecting.

ON RAGSDALE CREEK, six miles northwest of Canton, marble is found on *lot* 103, *14th district, 2nd section, owned by T. J. Carpenter.* It outcrops here at only one place on the hillside; but by sinking pits a few feet beneath the surface, it has been found underlying a small area in the creek bottom. Hand specimens of this stone are difficult to distinguish from the Cowart marble, and they evidently belong to the same stratum. The deposit does not appear to be very thick, and is usually unsound.

AT THE JUNCTION OF LOST TOWN AND SHOAL CREEKS, about eight miles northwest of Canton, quite an extensive outcropping of marble appears *on lots* 196 *and* 200, *22nd district, 2nd section, owned by J. M. White.* It is exposed for fully a quarter of a mile along the left bank of Lost Town creek, forming in places, bluffs several feet in height. The marble occurring here is generally sound; it contains fine sand, and is of a light-gray or pale-blue color. It dips to the southeast at an angle of 30° ; and, judging from the width of the exposure, the stratum must be nearly eighty feet in thickness. At the time of our visit, no prospecting had been done on this property.

CHAPTER VII.

THE SEMI-CRYSTALLINE MARBLES OF NORTH-WEST GEORGIA.

In a number of counties, within the Paleozoic area in Northwest Georgia, partly crystalline limestones occur. They are often heavy-bedded, and admit of a good polish. At a few places, in the counties below named, this stone may become of importance for economic purposes.

MURRAY COUNTY.

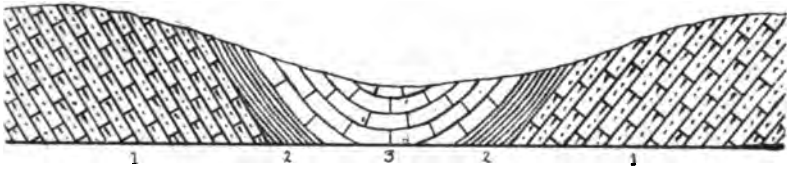
FIVE MILES WEST OF SPRING PLACE, at the base of Cedar Ridge, a great deal of work has been done in opening a quarry in the so-called black marble; but no merchantable stone, of any consequence has ever been put upon the market from this place. This stone, which has here been prospected, is a jet-black, carbonaceous limestone, belonging to the Oostanaula shales, and occurs in beds from six inches to two feet in thickness. It shows but little evidence of crystallization; but it admits of a fair polish. When struck with a hammer, the stone emits a peculiar odor, very similar to petroleum, and gives a beautiful conchoidal fracture. If exposed to the atmosphere, for any length of time, it undergoes a change in color, which is evidently due to some chemical change in the carbonaceous material. The thin beds, together with its change of color, is a serious drawback to this stone's ever becoming of any economic importance, as an ornamental stone.

WHITFIELD COUNTY.

There occurs in the northwest corner of this county a narrow belt of dark-chocolate and grayish marbles, highly fossiliferous. It enters the county from Tennessee, about one mile east of Red Clay, and extends nearly parallel with the East Tennessee, Virginia and Georgia division of the Southern Railway, for about ten miles.

It is well exposed about one mile east of Varnell's Station, on the Eslinger farm. This marble belongs to the same stratum, which traverses the valley of East Tennessee, and which is so extensively worked in the vicinity of Knoxville.

FIG. 11.



A section showing the position of the marble on the Eslinger farm, one mile east of Varnell's station. 1. Sandy ferruginous limestone. 2. Bluish shale. 3. Marble.

The color of the stone is quite variable. It is generally of a dark-chocolate color, variegated with white; but there also occurs, in more or less abundance, a light-gray and a beautiful pink. These various colors are frequently found at the same place, occupying different layers of the same stratum, or they may blend into one another, so that almost any shade of colors, from a dark-chocolate to a light-gray, can be secured. The light gray, which is always the most solid and the most completely crystallized, is generally traversed by dark, irregular lines, that add variety to an otherwise monotonous light-gray surface. The exposures are mostly in the form of bowlders, or large disconnected masses, which appear to be due to the surface weathering of thick layers of marble, with a somewhat jointed structure. As this peculiar mode of weathering has been caused entirely by surface waters, carrying carbonic acid in solution, it is reasonable to suppose that the bowlders and the disconnected masses unite to form continuous beds, at no great depth. These beds, making up the stratum of marble, as shown by the outcroppings, are from two to eight feet in thickness, and lie within a synclinal fold,[1] of a ferruginous calcareous formation, called, by Dr. Safford, iron-limestone.

It is difficult to determine the exact thickness of the marble deposit at any point along the belt, on account of the overburden

[1] See Figure 11.

of earth and the limited outcrops. However, one would be on the safe side, in putting the minimum thickness at thirty to forty feet. *On the Hoskin farm*, one mile southeast of Red Clay, it probably attains more than twice this thickness; but it is not all merchantable stone.

The microscopical and chemical analyses of the light-gray varieties of marble, show them to be nearly pure calcium carbonate, almost crystalline, with rarely any trace of organic remains. These chemical and physical properties, together with the smooth surface of the stones, exposed for years in the natural bed, are conclusive proofs, that the marble is well suited both for building and ornamental purposes.

The dark-chocolate variety has less calcium carbonate, and numerous fossils, and is only partly crystalline; but, owing to its beautiful color and brilliant finish, it is well adapted for furniture and interior decoration.

ON THE ESLINGER FARM, the marble was worked, many years ago, to a limited extent, into tombstones, some of which are still to be seen in the churchyards of the vicinity, in a fair state of preservation. The stone used for that purpose was mostly obtained from bowlders, and worked into the desired shape by hand. At other places along the line of outcropping, where the marble becomes thin bedded and easily quarried, it has been used locally in making chimneys, foundations for buildings etc.

The marble belt of Whitfield county is very favorably located for the shipment of stone. Branch lines can easily be constructed from the main line of the Southern Railway, along the numerous small streams, which cut through the ridge separating the marble belt from the railroad. Some of these streams are of sufficient size, and have enough fall, to give considerable water-power, that might be easily utilized in operating quarrying machinery.

FLOYD COUNTY.

About seven miles south of Rome, near Six Mile Station, a considerable amount of money was spent, a few years ago, in a black semi-crystalline limestone, belonging to the same formation, as that

PLATE IX.

Marble-dressing Works of the Kennesaw Marble Company, near Marietta, Georgia.

which has been worked for marble at the base of Cedar Ridge, in Murray county. The stone found here seems to have been much shattered and broken up, by some great dynamic force, and to have been again united by veins of white crystalline calcite. These white veins penetrate the stone in every direction, and give to it a very pleasing effect, when polished. A branch road nearly two miles in length was graded from this quarry to the main line of the Southern Railway, and quarrying machinery was purchased and put in operation; but the works were finally abandoned, before any stone was put on the market. The principal difficulty encountered, in using this stone for ornamental purposes, seems to be due to its unsound condition and its variable physical structure.

CHAPTER VIII.

MARBLE DRESSING WORKS.

The following is a short description of marble-dressing works, which, although not connected with any quarries, are, nevertheless, very important factors in the marble industry of the State.

THE KENNESAW MARBLE COMPANY.

The Kennesaw Marble Company was organized August 15, 1891, with a capital of $72,000. The plant operated by this company is located near Marietta, at the junction of the Western and Atlantic and the Marietta and North Georgia Railroads. It consists of a large mill, 420 x 80 feet, a machine-shop, a power-house, a packing and shipping building etc. The mill is supplied with twelve gangs of saws, three rubbing and two polishing beds, four turning-lathes, two large cutting-machines[1], one moulding and one countersinking machine, an electric dynamo etc. The machine shop is large, and well supplied with all the machinery, necessary to make or keep in repair all parts of the mill and the tools, used in cutting and carving the marble. With these various labor-saving machines and equipments, the company is enabled to turn out a great deal of excellent work at a comparatively small expense. A hundred and fifty horse-power Brown engine supplies all necessary power to run the machinery. The electric dynamo, which is located in the engine-room, furnishes the buildings with incandescent lights. This enables the mill to be run day and night, which is often necessary to fill pressing orders. The firm makes a specialty of monumental work and interior finish, though it is able to do all kinds of work, for which marble is used. It deals exclusively with contractors and retail dealers, and has worked up a very extensive trade in all the leading cities of the United States. The greater part of the marble used by this company is from the quarries of the Georgia Marble

[1] One of these machines cost $15,000.

Company in Pickens county. The output of the Kennesaw Marble Company, in the last three years, shows that the demand for the Georgia marble is rapidly increasing, and it has become one of our most popular ornamental stones. Recently, this firm has secured the contract to furnish, from Georgia marble, the interior finish for some of the most costly buildings, now being erected in the country. Among these may be mentioned the custom-house at Chattanooga, the new city-hall at Richmond, Va., and one of the corridors in the new congressional library at Washington, D. C. Many of the more expensive monuments of Georgia marble, which are now being put up throughout the South, are made by this company, who sell them to the local retail dealer ready for erection. The number of hands employed varies from time to time, the usual number being about seventy-five, though, when large contracts are to be filled on short notice, as many as one hundred and fifty hands are frequently employed.

THE BLUE RIDGE MARBLE COMPANY.

The works of the Blue Ridge Marble Company, located at Nelson, Pickens county, on the Marietta and North Georgia Railroad, is one of the most complete and thoroughly equipped marble plants in the State.

The company, organized in 1886, with a capital stock of about $100,000, manufactures, mainly of Georgia marble, all kinds of interior finish, monuments etc.; but, at present, it operates no quarries. The works, being within a short distance of the several marble quarries in Longswamp valley, and connected with them by railroad, are quite favorably situated for the selection of any material, which may be desired in filling various orders. The marble yard of the company, laid out on both sides of the railroad, covers several acres, and is usually well stocked with sawed blocks and slabs, ready to be worked, on short notice, into any desired shape or form. This display of the various grades and colors of the Georgia marble invariably attracts the attention of the traveler from the car window, and is always an object of general comment. Such object-lessons, however, unfrequently impress the observer with the importance of Georgia as a marble producing State.

The mill of the Blue Ridge Marble Company is large, well arranged and favorably located. It has ten gangs of saws, four rubbing-beds, and all the other necessary machinery used in fashioning and polishing marble. It is run by steam, and is frequently operated both day and night, when large orders are under contract. From fifty to seventy-five hands are usually employed about the works; but sometimes this number is increased to one hundred and fifty, in order to supply the demand for the class of work turned out by this firm.

The handiwork of the Blue Ridge Marble Company on the Georgia marble is not confined to this State, or even to the adjoining states; but it is sought from all parts of the country; instance, for example, their marble decoration of the famous Betz building, one of the most beautiful in Philadelphia, the Drexel Institute of the same city, and St. Cecilia's Church of Brooklyn, N. Y. One of the first contracts filled by this firm, was to assist in the interior finish of that magnificent building, the Auditorium at Chicago. Such, in brief, is the history of one of the first marble industries in the State.

GEO. B. SICKELS & CO.

The mill and shops of Geo. B. Sickels & Co. are located within a few hundred yards of the Georgia Marble Company's works, near Tate, where blocks of marble of any desired shape and color can be readily selected from the extensive stock, always kept on hand. The firm was organized in 1886, with a capital stock of $10,000; but, since then, the works have been greatly enlarged, in order to supply a rapidly increasing trade. They manufacture exclusively from Georgia marble, all kinds of interior finish, making a specialty of tiling and wainscoting, which find their way to all parts of the United States, and are generally commented upon, on account of the superior quality of the stone used, and the excellent workmanship. The mill has six gangs of saws and two large twelve foot rubbing-beds, run by an eighty horse-power engine.

The firm employs regularly about forty hands, and turns out, monthly, from twenty thousand to twenty-five thousand tiles, besides a great deal of wainscoting etc. From four to five car-loads of

manufactured material is usually kept on the yard, so that all small orders can be filled at once.

The following, taken from the company's price-list, shows the price and character of the material manufactured by this company:—

8 to 14 Inches Square, and 6 x 12 Inches to 12 x 24 Inches Ashlar.	7/8 Inches.	1 1/4 Inches.	1 1/2 Inches.
Kennesaw, Fancy—Pure White	$0.37	$0.49	$0.58
Kennesaw, A—Choice, Selected	.29	.38	.47
Kennesaw, B—Standard Grade	.25	.33	.41
Kennesaw, C—(No. 3)	.23	.31	.39
Cherokee, A—Choice, Selected	.29	.38	.47
Cherokee, B—Average	.25	.33	.41
Creole, A1—Choice, Selected, Dark	.29	.88	.47
Creole, A—Not Selected, Average	.25	.33	.41
Etowah, A—Choice, Selected, Pink	29	.38	.47
Etowah, B—Standard Grade, Pink and Dark	.26	.34	.42
Etowah, D—Choice, Selected, Salmon Pink and Gray	.28	.37	.46

Half and Quarter Tiles, 33 1/3 per cent. extra.

Border, in ordinary width, same price per foot as tile.

Border, less than 9 inches wide, will be figured in bill as 9 inches wide.

Border, over 18 inches wide, and extra length, pieces for doorways, 5 cents extra per superficial foot.

Corners taken off tile, 1 1/2 cents net, each.

Dots, boxed at $6.00 per hundred.

Boxing Tile, Halves and Borders, $1.75 per hundred square feet.

Hearths, 1 inch thick, sawed edges, per superficial foot, 20 cents net.

Imposing Slabs, 2 inches thick, 30 cents.

Wainscoting Slabs, 7/8 inches thick, 25 to 40 cents.

Coped to size, 10 cents extra per superficial foot.

Sand-rubbed, 5 " " " " "

Polishing, 10 " " " " "

Boxing, 5 " " " " "

Special discounts are made on single orders for large amounts.

CHAPTER IX.

SPECIMENS OF MARBLES COLLECTED.

While in the field, specimens of marbles were collected from all the outcrops. The collecting of specimens to form a museum, showing the State's mineral resources, is provided for, in the bill reorganizing the survey; and, as soon as sufficient material has been collected, a special room or rooms in the State capitol will be fitted up, when the marbles, as well as other building-stones, minerals, ores, fossils etc., obtained within the State will be permanently displayed. The specimens of marble secured for this purpose, where there are no quarries in operation, were ordinary rock specimens, trimmed three by four by one inches ; while, at the quarries, eight-inch cubes were secured, each face of which was differently finished, as shown by the accompanying plate. Figure 1 shows what is called the "rock-face," and is the rough surface of the stone, as it is taken from the quarry, or only slightly trimmed by a pitching-chisel.

The edges are sometimes surrounded by a narrow edge of "drove" work. The "rock-face" finish is used in exterior work, and makes a very attractive building, especially, if the white varieties of the Georgia marble are used. In figures 2 and 3, we have the "pointed-face," differing from the "rock-face," in having the surface of the stone trimmed down by an implement called a point. This style of finish is also largely used in exterior work, two varieties of which are here represented. Figure 4 represents the "tooth-chiseled" finish, and is produced by means of a wide chisel, having its edge toothed like a saw. Figure 5 shows the "square-drove" finish, made by a chisel resembling that used in making the tooth-chiseled face, but differing from it, in having its edges smooth, instead of notched. This style of finish is shown as a margin to all the faces here figured. It is frequently used as a margin to pointed or rock faces. The "patent-hammer" finish is produced by the patent hammer,

an instrument formed of four, six, eight, or more thin steel plates, fastened securely together, so as to form a single piece, the striking face of which makes, when it comes in contact with the marble, a number of alternating, parallel grooves and ridges.[1] This style of finish gives to the surface of the Georgia marble a snow-white appearance, and is used for exterior work. The polished surface, which cannot be shown by figure, is frequently used on interior decoration, table-tops, tombstones etc. It may be produced, by the use either of oxalic acid or polishing putty. The surface of the stone is first made as smooth as possible, by means of sand or emery and pumice or hone, after which it is rubbed with a woolen cloth, wet with oxalic acid, or charged with polishing putty, either of which produces a very brilliant polish, though the former is not so durable as the latter.

The State Museum is greatly indebted to the Georgia Marble Company and the Southern Marble Company for five eight-inch cubes, furnished by each company, showing the marbles dressed, as above described.

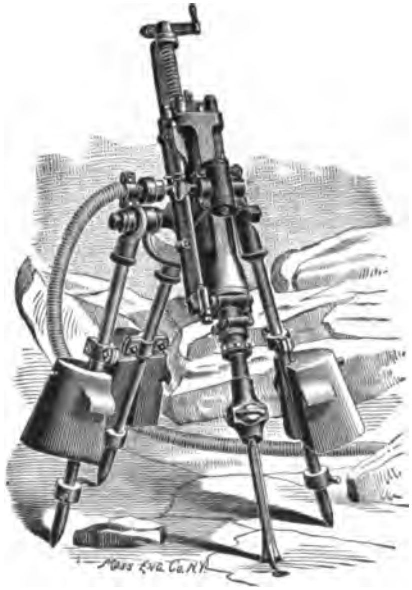
[1] See plate XV, figure 6.

CHAPTER X.

MACHINES AND IMPLEMENTS USED IN MARBLE-WORKING.

The following descriptions of machines and implements, used in working marbles, are taken from the report of the United States National Museum for 1886,[1] with slight changes.

Fig. 12.



THE ECLIPSE ROCK DRILL.

Of the many machines, that have, from time to time, been invented for working stone, we can here mention only the principal ones, that are to-day in actual use.

[1] "The collection of Building and Ornamental Stones in the United States National Museum: A Hand-book and Catalogue. By George P. Merrill, Curator of the Department of Lithology and Physical Geology," 1889. As this book is out of print, Dr. Merrill has added much new matter to the original, and it is now published by John Wiley and Sons, New York City, under the name, Stones for Building and Decoration.

Marble-dressing Works of the Blue Ridge Marble Company, Nelson, Pickens County, Georgia.

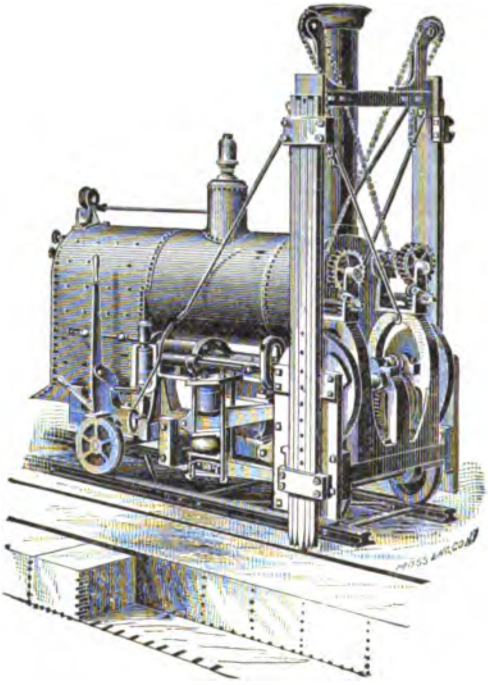
Drills.—The old-time method of drilling by means of a flat, pointed drill, called a "jumper," which is held by one workman, while others strike it alternate blows with heavy hammers, although still in use in many quarries, has been largely superseded by steam-drills of various kinds.

A simple form of the steam-drill, and one now in very general use, is that shown in figure 12. The drill proper is fastened directly to the piston, which can be inclined at any angle, thus fitting it for ordinary quarrying or tunneling. It is driven either by steam or compressed air. A different adaptation of the same principle is employed in channeling and gadding machines, used in getting out dimension stones. The drill and cylinder are attached to the horizontal bar, by means of a clamp, which can be loosened or tightened at will. By this means a dozen or more holes can be cut by simply sliding the drill along the bar, without moving the entire machine.

Channeling-Machines.—The channeling-machine, shown in figure 13, was invented by *George J. Wardwell* of Rutland, Vt. The first successful machine was built by him in 1863, in connection with the Sutherland Falls Marble Company, and that original machine was at work there constantly, until 1885. These machines are used by the Georgia and Southern Marble Companies, and are in operation at all the important quarries of sandstone, limestone and marble in the country. It is calculated, that over 5,000,000 square feet have been cut by them. The channeler is essentially a locomotive machine, driven by power, usually steam, moving over a steel rail track, which is placed on the quarry-bed. It carries a single-gang drill on one side, or two such drills, one on each side. These are raised and dropped by a lever and crank arrangement. The gang of cutters forming the drill is composed of five steel bars, 7 to 14 feet in length, sharpened at the ends and securely clamped together. Of the five cutters, two have diagonal edges; the other three have their edges transverse. The center of the middle cutter, which is the largest, extends lowest, so that the five form something like a step arrangement away from the center. The drill, lifted, drops with great force, and rapidly cuts a channel

into the rock. The single-gang machine is operated by two men, and the double one by three. As it runs backward and forward over the rock, the machine is reversed without stopping, and, as it goes, the cutters deliver their strokes, it is claimed, at a rate of one hundred and fifty per minute. The machine feeds forward on the track, half an inch at each stroke, cutting half an inch or more at

FIG. 13.

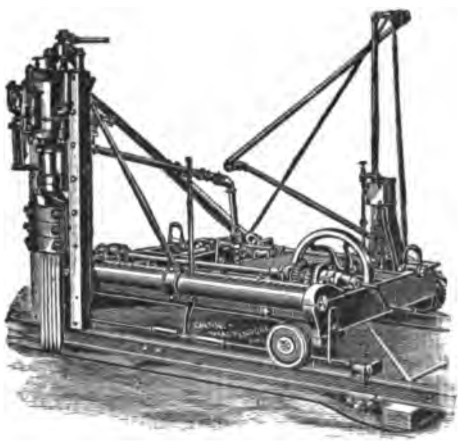


THE WARDWELL CHANNELING MACHINE.

every time of passing. The single machine will cut from 40 to 80 square feet of channel per day in marble or limestone, at a cost of from 5 to 20 cents per square foot. The double machine will do twice the amount of work, in the same time. A good workman would formerly cut from 5 to 10 feet, that is, a groove one foot deep and from 5 to 10 feet long, in one day. For this, he would receive from 25 to 30 cents per foot.

Sullivan's Channeling-machines are also used at the Georgia and Southern works. They differ from the Wardwell in several important particulars, prominent among which are these:—1. The cutting-tool is attached rigidly to the piston, so that the stroke is dealt directly by the steam pressure in the cylinder, and without the intervention of any cranks, levers or springs. 2. The cutting-tools are made adjustable to any angle—to the right, left, forward or backward. The machine is thus capable of making transverse and side-hill cuts, and does what is known in quarrying as "cutting out the corners." 3. It can be used in chambers, where the distance between the floor and the roof is but 6 feet; and it can be used in tunnels and headings. The machine carries five drills in the gang, three straight points and two diagonal ones. These are arranged as seen in the accompanying cut.

FIG. 14.



THE SULLIVAN CHANNELING MACHINE.

The average capacity, as claimed by the company's circular, is as follows:—

In marble, 80 to 100 square feet of channel, in ten hours.

In sandstone, 150 to 200 square feet of channel, in ten hours.

In limestone, 120 to 150 square feet of channel, in ten hours.

The Ingersol-Sergeant Channeling-machine is another first-class machine, which is in use at the Piedmont quarry. The principal

points of superiority claimed by the builders of this channeler are its unusually heavy construction of truck-frame, channeler-engine, striking parts etc.

The Diamond Channeling-machine, though not at present used in the Georgia quarries, employs 1¾ inch drill-bits, which are attached to the drill-rods of varying lengths, adapted to any required depth of channel up to 9½ feet. The channel may be made open or partly closed, the latter by leaving slight spaces between the holes, to be afterwards chipped out. But the whole operation of a clear cut is made simultaneously by means of an intercutting guide, which answers this purpose very well. The drill can be made to vary in any direction, from perpendicular to a 50° slant, for putting down the tunnel and angle cuts.

GADDERS.—The gadder takes its name from the class of work, for which it is especially designed, and which is known among quarrymen as "gadding." When the requisite channel-cuts are made about a block of marble to be removed, it is necessary to undercut the block, in order to release it. This is usually accomplished by drilling a series of holes beneath it, and then, by wedges, the block is split from its bed.

The machine is placed upon a platform on trucks, arranged to run on a track. When adjusted for work, it may be braced by pointed legs. The boring apparatus is attached by a swivel to a perpendicular guide-bar. This guide-bar is secured to the boiler behind it, which forms the main support of the machine. Upon the guide-bar, the boring apparatus may be raised or lowered at will, for the purpose of boring a series of holes in a perpendicular line, if desired. Upon the swivel, the boring-apparatus may be turned, so as to bore in any direction, within the plane of the swivel-plate. At one end of the drill-rod or spindle is the drill-head, armed with carbons, and supplied with small apertures or outlets for water. At the other end of the spindle is attached a hose for supplying water to the drill-head. A rapid revolving movement is communicated to the drill-spindle by the gearing. The speed and feed-movement may be regulated by the operator with reference to the hardness or softness, coarseness or fineness of the material to be bored; and the

feeding movement may be instantly reversed at pleasure. The machine is so constructed, that the drill-spindle may be removed, and others inserted in the same holder, adjusted to bore in the opposite direction, the boring apparatus being driven by a double-cylinder engine. A continuation of one of the piston-rods through the cylinder forms the plunger to a small pump, placed above the cylinder, which supplies water to the boiler, and forces water through the drill-spindle and head. These jets of water wash out all the borings made, and keep the drill-head from heating. The usual feed of this drill in marble is from four to five inches per minute.

The Ingersol Golding Machine is used in the Georgia marble quarries; it is only a special adaptation of the steam-drill. It is claimed, that this machine will "put in holes, close to the bottom of the quarry, in a horizontal position along the bench, into the roof, or perpendicularly into the floor as desired."

Grinding and Polishing Machines.—In large works, the grinding and polishing is now generally done by steam power. For flat surfaces, a circular, horizontally revolving iron plate or grating, attached to the lower end of a vertical shaft, with elbow joint, is used; the workman guides it to any portion of the surface he may desire, by means of a handle, the abrading substance being sand or emery. With felt attached to the plate, the same form of machine is also used for polishing. Blocks of such size, as can be handled by the workmen, are usually ground upon horizontal revolving iron beds, some eight or twelve feet in diameter. In making straight or only slightly curved moldings, the form is first carved out with a chisel, and then a plate of cast-iron, fitting as accurately as possible, is made by means of a long arm, to travel back and forth over the stone, with sand or emery, or putty-powder and felt, as the case may be. These are called pendulum-machines. The actual labor is thus greatly reduced, and a higher and more lasting polish obtained, than is possible by hand.

Lathes and Planers.—Lathes are now very generally used, for turning posts and pillars from soft stone, as well as from granite. In easy working varieties, as sandstone, limestone and marble, the cutting tool is a simple chisel, much like that used in turning metals,

and is held in a clamp in the same way. With the softer varieties of stone, a plane surface, sufficiently smooth for flagging, is produced by means of a planing machine, similar to those in use for planing metals, and is operated in the same manner.

MACHINES FOR SAWING.—In sawing marble, the same method, with some modifications, is employed, as was in use according to Professor Seeley, three hundred years before the Christian era. The principal consists simply of a smooth flat blade of soft iron, set in a frame and fed with sharp sand and water. The saws are now frequently set in gangs of a dozen or more in a single frame, and several gangs are sometimes operated by one man, who shovels on the wet sand, as it is needed, while fine streams of water from overhead wash it beneath the blade, as it swings backward and forward in its slowly deepening groove. Some attempts at automatic feeders have been made; but they are not, as yet, in general use.

This method has been found to be inapplicable for cutting granite, owing to the greater hardness of the material. In the last few years, a sand, composed of globules of chilled iron, has been used to good advantage. The great drawback to the use of this material, so far as observed, is the care necessary to avoid staining the stone by rust from the wet globules, during the time the machine is not running. This is done by wetting down the stone and globules in the saw-frame, with a thick solution of lime-water, prior to leaving the saws for the night. Circular saws, with diamond teeth, have been used to some extent; but they have not come into general use, on account of being too expensive.

For sawing circular apertures in the top of a washstand, or getting out tops for small tables, a saw, made of plates of soft iron bent into the form of a cylinder and revolved by a vertical shaft, is used. Sand, emery, or globules of chilled iron constitute the cutting materials, as with the saws just mentioned.

A recent European invention for sawing stone consists of a twisted cord of steel, made to run around pulleys like a band-saw. The cord is composed of three steel wires loosely twisted together, but stretched tightly over the pulleys, and is made to run at a high rate of speed. The swift successive blows from the ridges of cord,

delivered along the narrow line, disintegrate the stone much more rapidly, it is claimed, than the iron blade fed with sand. The usual rate of cutting in blocks of soft limestone is about twenty-four inches an hour, and, in marble, a little more than nine inches an hour. In certain Belgian marble quarries, the saw is said to be used to advantage in cutting the rocks from the quarry-bed. In thus utilizing it, the floor is first cleared, as for channeling-machines, and then, by means of large cylindrical drills, fed with metallic sand, a shaft twenty-seven inches in diameter is cut to the desired depth, and the cores are taken out, as by the common tubular diamond-drill. Two of these holes are sunk at proper distances apart, and guides are set up in them, on which movable frames are placed, carrying pulleys of a diameter somewhat less than that of the holes; over these pulleys the cord-saw is stretched; motion is then imparted to the pulleys by a simple system of transmission, and the saw cuts without interruption, until the bottom of the drill-pit or shaft is reached. A great saving of time and material is claimed for this invention. Although it seems to promise well, none are, as far as is known, in use at present in this country.

THE SAND-BLAST.—The sand-blast has been utilized to some extent, in the work of lettering headstones, and for producing delicate tracings on quartzite. That the process is so little used is due, it is said, to the opposition of the trades-unions, and not to any defect in the process itself.

HAND IMPLEMENTS.—*The Face Hammer.*—This is a heavy square-faced hammer, weighing from fifteen to twenty-five pounds, and is used for roughly shaping the blocks, as they come from the quarry. It is sometimes made with both faces alike, or again with one face flat, and the other drawn out into a cutting edge.[1] The cavil differs from it, only in having one face drawn out into a pyramidal point.

The Ax or Pean-hammer is made with two opposite cutting faces, as seen in figure 13, plate XVI. The edges are sometimes toothed roughly, when it is called the toothed-ax.

[1] See figure 10, plate XVI.

The Patent or Bush-hammer[1] is made of four, six, eight, ten or more thin blades of steel, bolted together, so as to form a single piece, the striking faces of which are deeply and sharply grooved. This hammer is said to have been invented by Joseph Richards of Quincy, Mass., at some time between the years 1831 and 1840. As constructed, this head was composed of a single piece, instead of several as now. In some works this is called a bush-hammer.

Crandall.—This consists of a bar of malleable iron about two feet in length, and slightly flattened at one end, through which is a slot, three-eighths of an inch wide and three inches long. Through this slot are passed ten double-headed points, of one-fourth of an inch square steel, nine inches long, which are held in place by a key.

Sledge Hammer.—A smooth-faced hammer, weighing from ten to twenty-five pounds, used for striking the drills, in hand-drilling, or in driving large wedges for slitting stone.

Hand-hammer.[2]—A smooth-faced hammer, with two striking faces, weighing from two to five pounds. It is used for hand-drilling, pointing and chiseling in hard kinds of rocks. It usually has both faces alike.

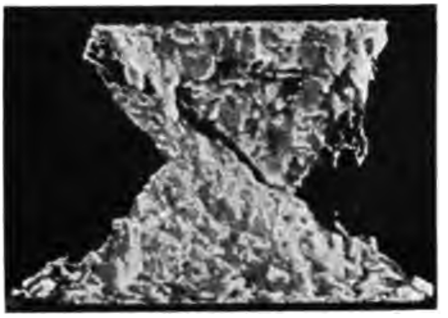
Mallet.—This is a wooden implement, with a cylindrical head, used in place of the hammer in cutting the soft stones, as marbles and sandstones.[4]

Pick.—An instrument resembling the ordinary pick-axe used in digging, but somewhat shorter and stouter. It is used on soft varieties of stone, for rough dressing or channeling, prior to wedging.

Pitching Chisel.[3]—This is a steel chisel, the cutting face of which is rectangular in outline, and with sharp angles or corners. It is used for trimming down the edges to a straight line. The *Chipper* is used for similar purposes.

Chisel or Point.—This is a steel chisel, the cutting edge of which is drawn out wide and thin, as shown in figure 2, plate XVI. It is used,

[1] See figure 12, plate XVI.
[2] See figure 11, plate XVI.
[3] See figure 16, plate XVI.
[4] See figure 13, plate XVI.
[5] See figure 7, plate XVI.



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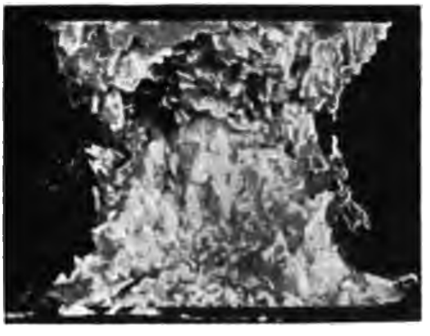

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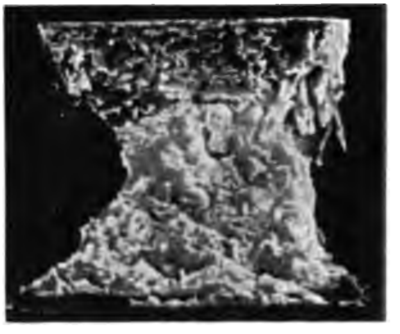

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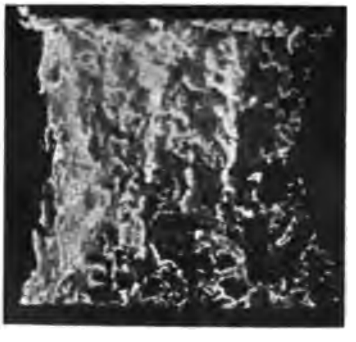


4.

ONE-INCH CUBES OF MARBLE, AFTER HAVING BEEN SUBMITTED TO CRUSHING TESTS.

No. 1. Creole,	crushing strength,	13,200	lbs.
" 2. Kennesaw,	" "	10,000	"
" 3. Etowah,	" "	13,200	"
" 4. Southern,	" "	10,900	"

principally, on the soft varieties of rock, in producing what is called "drove-work."

Splitting Chisel.—A steel chisel, made as shown in figure 8, and used in splitting and general cutting on hard stone like granite. Other forms of chisels, used only on soft stone and driven with a wooden mallet, are shown in figures 3 and 6, plate XVI.

Tooth Chisel.[1]—A chisel like the drove-chisel, but with the edges toothed like a saw. It is used, only on soft stones, like marbles and sandstone.

Point.[2]—A steel implement, with the cutting end in the form of a pyramidal point, used in the production of the finish known as "point-work," and also in the smoothing down of rough surfaces, prior to using the ax or some other tool for fine work. Points for use on hard stone, and driven by the hammer, have the upper end finished as shown in figures 6 and 7, plate XVI.

Wedges or Plugs.[3]—The steel wedges used vary greatly in size. Those used in the process of splitting, called "plug and feather," are but two or three inches in length, while those used in quarrying for splitting off large blocks, are often a foot or more long and correspondingly large.

Hand-Drill.[4]—A small drill from eight to fifteen inches in length, held in one hand and driven by the hand-hammer, is used for making holes for "plug and feather" splitting, and for other light work.

Grub-Saw.[5]—A saw for cutting stone by hand. It consists of a plate of soft iron, from a twentieth to a tenth of an inch in thickness, and from six inches to four feet in length; the blade is notched on the lower end, and fitted with a wooden back, for convenience in handling and to prevent bending. Sand or emery is the cutting material, as with the steam saws.

[1] See figure 1, plate XVI.
[2] See figure 4, plate XVI.
[3] See figure 14, plate XVI.
[4] See figure 5, plate XVI.
[5] See figure 17, plate XVI.

CHAPTER XI.

PHYSICAL TESTS OF THE GEORGIA MARBLES.

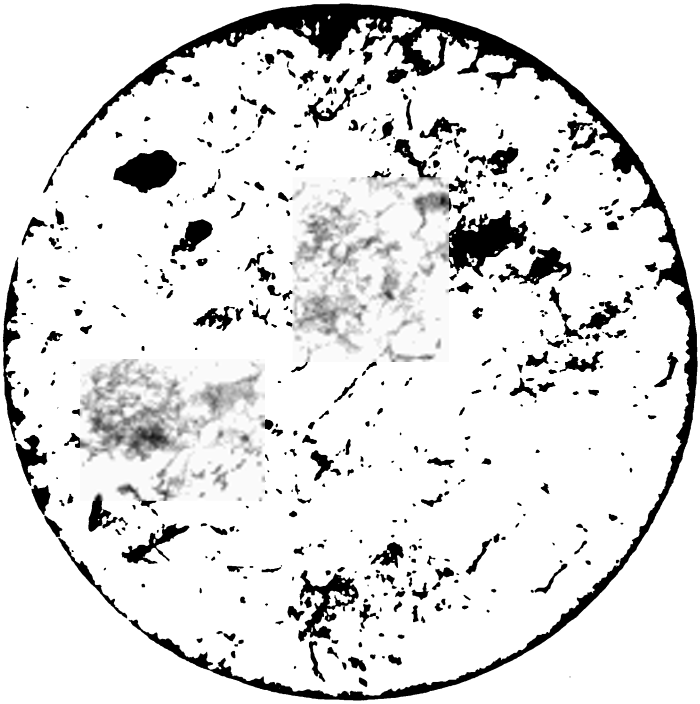
THE MICROSCOPIC STRUCTURE OF MARBLES.

Though the use of the microscope in the study of rocks is of recent date, yet it has rendered invaluable aid, in making out the structure and the composition of rocks, which are always the most important points to be considered in selecting a building stone. By this means, the most minute impurities or defects, which might give rise to uneven weathering or to rapid disintegration in a stone, can frequently be readily detected. A chemical analysis gives the ultimate chemical composition of a rock, while a microscopic analysis gives its mineralogical composition, showing in what form the chemical elements are combined, and how different two rocks may be in structure and texture, though nearly alike in chemical composition. Thus, for instance, take two limestone hand-specimens, which closely resemble each other. When subjected to chemical analysis, they are found to be identical in composition; but, on examining them, in thin sections under the microscope, they are seen to be very different in structure, one being phenocrystalline, while the other is cryptocrystalline. By the aid of the microscope, we are also able to follow every phase of crystallization, and to explain many otherwise unknown parts of the history of many of our building stones, and the changes, which they are likely to undergo, when subjected to new conditions.

In order to study fragments of rocks under the microscope successfully by transmitted light, it is necessary that they be made so thin, that the darkest colored stone may become at least partly transparent. The manner of preparing thin sections depends mainly on the means at hand for executing the work. When no stone-cutting machine is to be had, thin chips or flakes can usually be broken from the stone, of the desired shape and thickness, by means of a hammer; but, when it is desired to make a section in some particular

direction through a rock, it is essential to have recourse to a machine, in order to get satisfactory results. A number of machines have been devised for this purpose, several of which are said to do very satisfactory work. The one belonging to the laboratory of the Geological Survey of Georgia was devised by the late Professor George H. Williams, of Johns Hopkins University; it is probably one of the best now in use for small laboratories. Slices, about one thirty-second of an inch in thickness, are cut by this machine, by pressing the stone against a rapidly revolving metallic disk, having diamond-dust set in its edge. It is run with a small dynamo, supplied with electricity from a three-cell storage battery. This machine has also attached to it a horizontal grinding disk of copper, on which the slices can be ground to the desired thinness. Having obtained thin slices of the stone, either by use of the section machine, or by detaching thin chips with the hammer, the next process is to prepare them for the microscope. This is done by rubbing down one side of the specimen, until it becomes perfectly flat and smooth, either by grinding it by hand on a flat surface of plate glass, with emery and water, or by using the same abrasive material on the horizontal revolving disk of the section-machine. When the necessary machine is at hand, the latter method is always preferable, on account of the rapidity with which the work can be executed. The chips used in making sections are usually about three-quarters of an inch in diameter; if not of convenient shape to be pressed flat by the finger against the grinding surface, the fragment to be ground must be cemented to a bit of wood, in order to hold it steady before proceeding to rub it down. When the desired flatness and polish have been obtained, and all the dirt and particles of emery have been thoroughly removed from the surface, the next process consists in cementing the smooth surface of the stone to a small piece of plate glass about two inches square and a quarter of an inch thick. The specimen, with its polished face downward, is fastened to the plate glass by means of Canada balsam, which becomes quite hard, after being heated, and forms a strong union between the smooth surfaces. The slice thus firmly attached to the glass can be easily held in position on the grinding-surface, until it has been reduced

to such a degree of tenuity, as to become transparent. It is then transferred to a new glass slide, mounted in Canada balsam, and covered by a thin cover-glass, when it is ready for examination under the microscope. The microphotographs, used in this report, were made by photographing through the microscope, thin sections of marble, prepared as above described. The same magnifying power, which was about fifty diameters, was used in all cases except for the specimen of Etowah marble, where twenty-five diameters was used.



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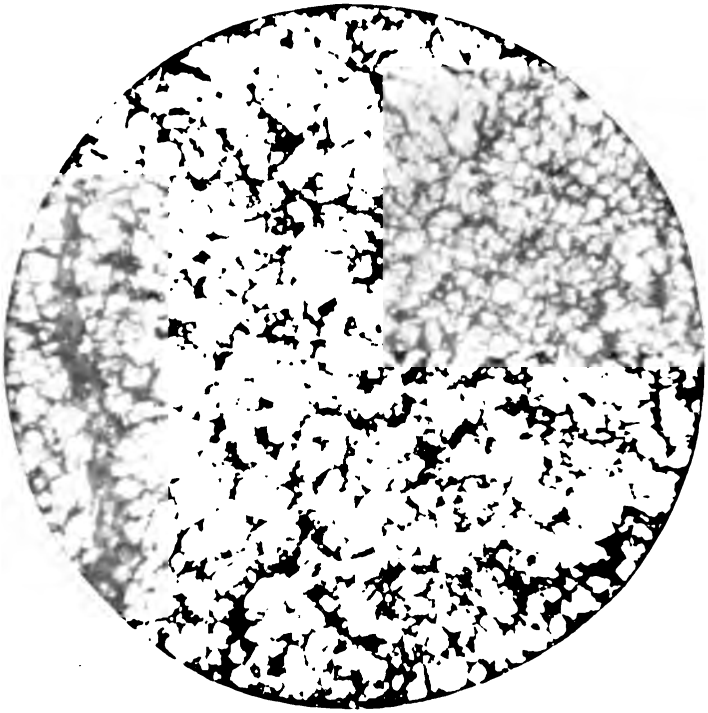

2.

MICROPHOTOGRAPHS OF GEORGIA MARBLE.

1.

A microphotograph[1] of marble from G. W. Crain's property, near Canton, Cherokee county, magnified fifty diameters. The section shows very small grains of calcite, through which are irregularly scattered a small amount of foreign substances. Besides mica and magnetite, various minute needles of light colored amphibole (?) may be seen. Some of these impurities occur in sufficiently large grains to be seen with the unaided eye, and give to the surface of the marble, when weathered, a roughened appearance.

2.

A microphotograph of dark colored marble, from a quarry near Six Mile Station, Floyd county, magnified fifty diameters. The individual granules of calcium-magnesium carbonate, making up this marble, as shown by the section, are quite small, and are frequently separated from each other, by carbonaceous material, which gives to the stone its dark color.

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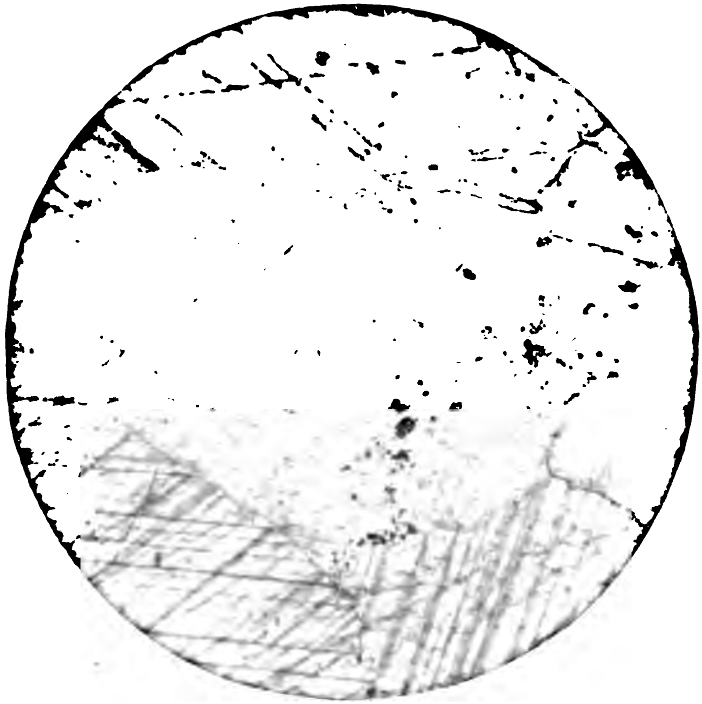
[1] The Survey is under obligations to Professor F. Lamson Scribner, of the Agricultural Department, Washington, D. C., for the use of instruments and for aid, in making the microphotographs here shown.

3.

A microphotograph of the Creole marble from the Georgia Marble Company's quarries, Pickens county, magnified fifty diameters. The section shows very large grains of calcite, through which are unevenly distributed minute scales of graphite, that give to the stone its dark or blue color.

4.

A microphotograph of marble from Marble Bluff, Gilmer county, magnified fifty diameters. A moderately fine-grained marble, with small scales of mica, as inclusions.



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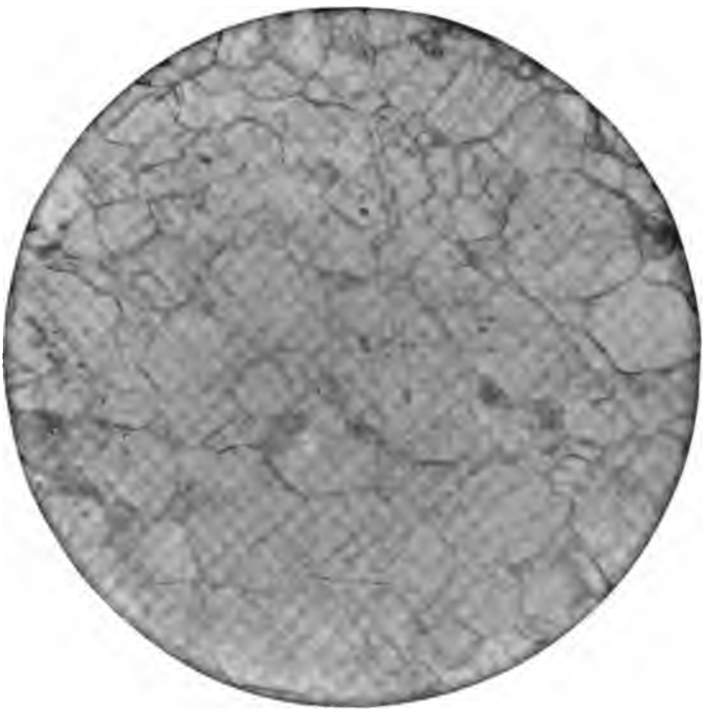
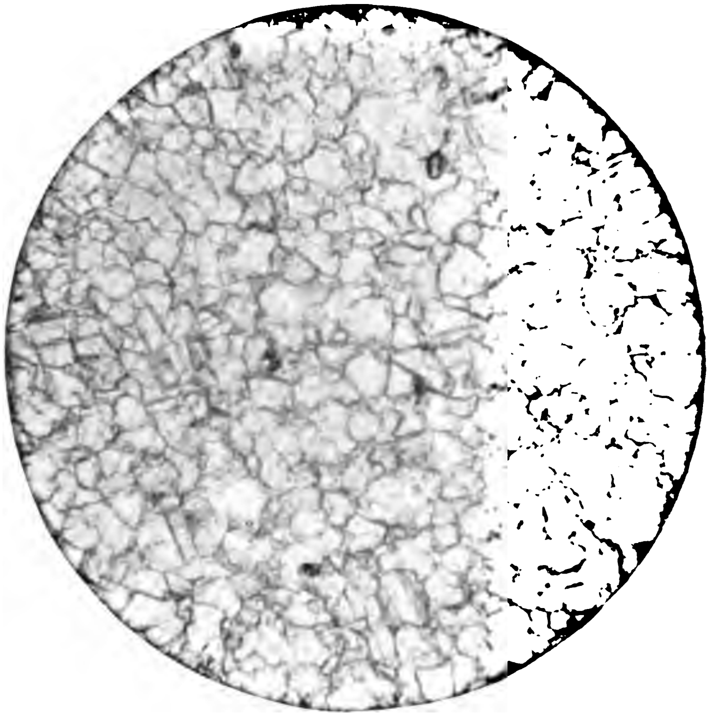


4.

MICROPHOTOGRAPHS OF GEORGIA MARBLE.



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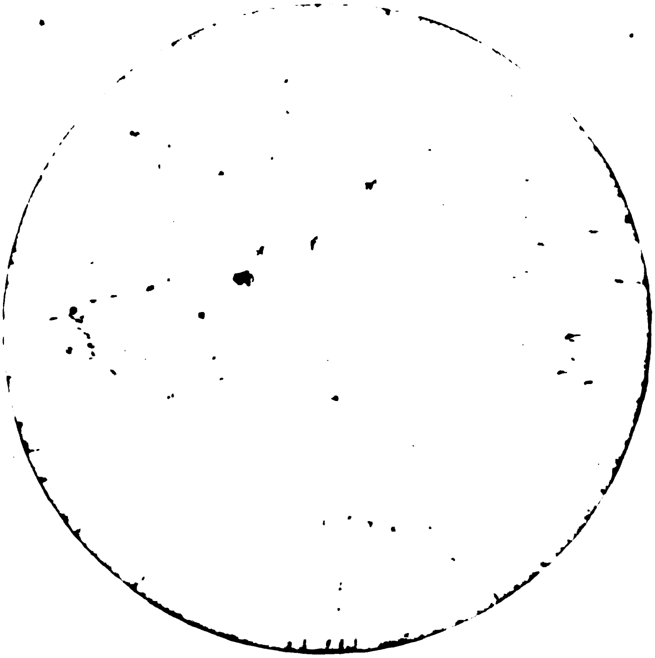


6.

MICROPHOTOGRAPHS OF GEORGIA MARBLE.

5.

A microphotograph of light colored dolomitic marble, from a quarry one mile east of Mineral Bluff, Fannin county, magnified fifty diameters. This is quite fine-grained, and has few impurities.

6.

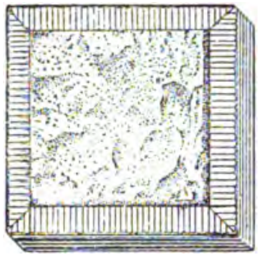
A microphotograph of marble from the Etowah quarry, Pickens county, magnified twenty-five diameters. The specimen, from which this section was taken, was of a beautiful flesh color; but this color seems to entirely disappear, when it becomes sufficiently thin to be studied under the microscope. The dark specks near the center of the section are mica, which occurs sometimes quite plentifully along definite lines.

CRUSHING TESTS.

The crushing tests were made at the University of Tennessee on an Olsen testing-machine, which has a capacity of 20,000 pounds. Inch cubes were used, or as near that size as could be secured. The upper and the lower compressed surfaces of the cubes were protected in all cases, by means of a dense cardboard about one-sixteenth of an inch in thickness. The object in using these pads was to secure, as near as possible, a uniform degree of pressure on all points of the compressed area. This precaution would have been unnecessary, if the opposite sides had been exactly parallel; but probably in no case was this absolutely true. All the specimens produced, in crushing, a theoretical break; that is, each cube, after being crushed, formed a double cone, whose bases were the original compressed faces of the cube.[1] This break shows the specimens to be sound, and that the weight was distributed equally over the entire surface. The comparative strength per square inch, as given by these tests, is much higher, than that of many of the marbles used for building and ornamental stones in the United States; especially is this true of the Creole and Etowah marbles, from the Georgia company's quarries. Of the twenty-five crushing tests of marbles given in the tenth census report on building-stones of the United States, only five samples surpass these in strength. It will be seen by comparing this table with the one on absorption, that there is an obvious relation between the ultimate strength and the porosity, as shown by the amount of water absorbed, the more porous being the easiest crushed. Both the specific gravity and the weight per cubic foot are high, which shows the stone to be quite dense and free from pores; this is also verified by the absorption tests.

[1] See plate XI.

PLATE XV.



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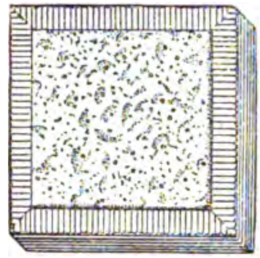

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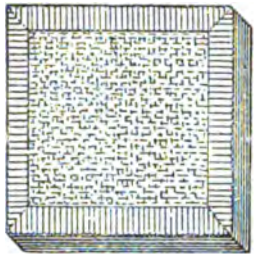
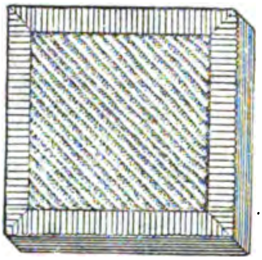
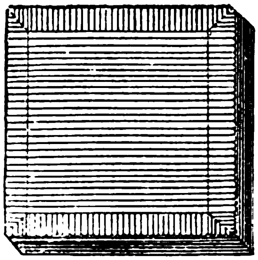


3



4



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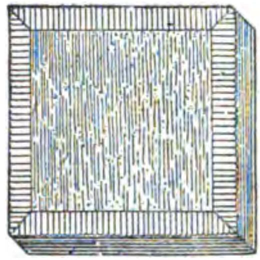


6

KINDS OF FINISH.

Fig. 1. Rock Face. Fig. 4. Tooth-Chiseled.
Figs. 2 and 3. Pointed Face. Fig. 5. Square Drove.
Fig. 6. Patent Hammered.

CRUSHING TESTS[1].

NAME.		QUARRY.	Compressed Surface in inches.	Position.	Actual crushing load in pounds.	Compressive strength per square inch in pounds.	Reduced to correspond to pressure per sq. in. on 2 in. cubes[2], in lbs. per sq. inch.	Specific gravity.	Weight per cubic foot in pounds.	REMARKS.
Kennesaw,	No. 1	Kennesaw......	.99 x .99	Bed.	10,000	10,204	12,244	....	....	Cracked on edge before bursting.
"	" 2	Kennesaw......	1.00 x 1.00	"	11,400	11,400	13,680	2.717	169.8	Burst suddenly.
"	" 3	Kennesaw......	1.00 x 1.00	"	10,672	10,672	12,806	....	....	Burst with explosion.
Creole,	" 1	Georgia	1.00 x 1.00	"	13,900	13,900	16,680	....	....	Burst with explosion.
"	" 2	Georgia	1.00 x 1.00	"	13,100	13,100	15,700	2.763	172.6	Burst with explosion.
"	" 3	Georgia	1.00 x 1.00	"	13,200	13,200	15,840	....	....	
Etowah,	" 1	Georgia	1.00 x 1.00	"	13,200	13,200	15,840	....	....	
"	" 2	Georgia	.99 x .99	"	12,000	12,244	14,692	2.707	169.1	
"	" 3	Georgia	.99 x .98	"	12,300	12,540	15,048	....	....	
Southern,	" 1	Southern	.99 x 1.00	"	11,300	11,414	13,696	....	....	
"	" 2	Southern	.99 x 1.00	"	10,900	11,010	13,212	2.734	171.8	
"	" 3	Southern	.98 x 1.00	"	10,800	11,020	13,224	....	....	

[1]The Survey is under obligations to Professor Chas. Ferris of the Engineering Department of the University of Tennessee, for valuable aid rendered in making the crushing and absorption tests.

[2]General Q. A. Gillmer, in his report on the compressive strength of building stones of the United States, Appendix II, Annual Report of the Chief of Engineers for 1875, determined a general formula for converting the crushing strength of different cubes into each other. In applying this formula for one and two inch cubes, it is found that the crushing weight of the smaller cube should be increased by approximately one fifth of itself, in order to compare correctly the strength of the two cubes.

ABSORPTION TESTS.

NAME.	Weight, after drying for 24 hours.	Weight, after remaining in water for 72 hours.	Approximate percentage of absorption.
Kennesaw	45.160 grammes.	45.200 grammes.	.008 per cent.
Creole	44.320 "	44.335 "	.004 " "
Etowah.........................	42.215 "	42.240 "	.005 " "
Southern, No. 1.	46.170 "	46.200 "	.006 " "
Southern, No. 2	44.440 "	44.475 "	.008 " "

In making the absorption tests, one-inch cubes were used. All, except Southern No. 2, which was polished, had sand-rubbed surfaces, and had been lying in the office for about four months. After being exposed to dry air, at a temperature of 212° Fahrenheit, for twenty-four hours, they were carefully weighed and then placed in water at a temperature of about 60° F., for seventy-two hours, and were again weighed. The difference between these weights shows the amount of absorption, which, divided by the weight before immersion, gives the percentage of absorption. The amount of moisture taken up in each case, as shown by the percentage of absorption, was extremely small; especially was this true of the Creole and the Etowah marbles, which absorbed less than one part in two thousand. This test proves, that the stone is practically free from all pores or openings, into which water or any other foreign matter can penetrate, so as to cause disintegration or change color. By comparing the specimens from the Southern marble quarries, Nos. 1 and 2, it will be seen that the latter, which was polished, absorbed more moisture than the former, which had been only sand-rubbed. This difference in absorption seems to have been entirely due to the physical condition of the surfaces; for, otherwise, the specimens appeared to have been identical in every respect. It will be further noticed, that the marble from the Kennesaw and the Southern quarries, which are located near each other, have a slightly higher percentage of absorption, than the marble (Creole and Etowah) from the Georgia quarries. This is probably accounted for, by the smaller crystalline grains of the latter, which appear to form a somewhat more compact stone than the former.

CHAPTER XII.

CHEMICAL DISCUSSION OF THE MARBLES OF GEORGIA.

BY W. H. EMERSON, PH.D.

The most valuable properties of marble for structural purposes being strength and durability, for ornamental purposes, color and texture, it would be desirable, in this chapter, to trace the relations between strength, durability, color, texture and chemical composition. Unfortunately, such cannot be done with any degree of fullness or certainty; only a few isolated facts can be noted. The difficulty in establishing such relations is mainly due to the fact, that composition is only of secondary importance, especially in determining strength and durability, these properties being far more dependent on physical structure., Scarcely anything has been done in studying the relations between the properties and structure; so that the effects of composition are complicated by the effects of the practically unknown factor—structure. As has been stated above, marble is essentially calcium-carbonate, a salt having, as its negative element, carbonic acid, one of the weakest acids, being easily displaced from its compounds by most other acids. As a consequence, marble is very sensitive to the action of chemical agents, everywhere present in the àtmosphere. The substances normally present in the atmosphere, causing the destruction or weathering of building-stones, are carbonic and nitric acids, oxygen and ammonia; while in the towns and cities this list is augmented by hydrochloric, sulphuric, sulphurous and organic acids, derived from the combustion of coal, chimneys of chemical manufactories, decay of vegetable matter etc. While marble is more rapidly attacked by chemical agents than other stones, its power to resist the mechanical agents of weathering, which are generally the most destructive, makes it a comparatively durable stone.

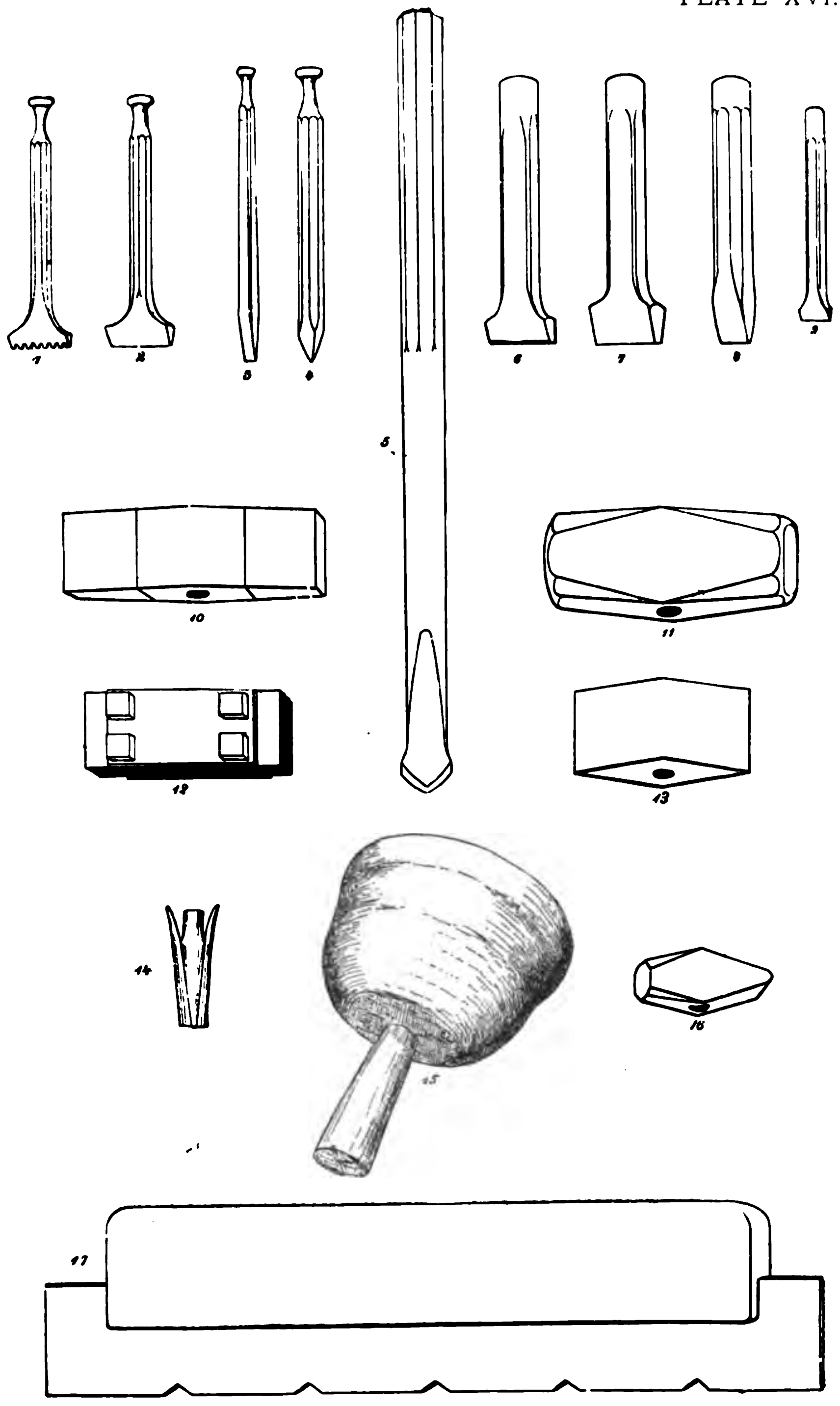
Beside the essential constituent, calcium carbonate, marble always contains some of a large variety of accessory substances, one of which, magnesium carbonate, may vary indefinitely, from calcite, on the one hand, to magnesite, on the other; and, when the proportion is such as to give equal molecules of the two carbonates, the name dolomite is applied. Pure calcium carbonate is easily dissolved in large pieces by cold dilute hydrochloric acid, as is evidenced by the brisk effervescence; while dolomite, under the same circumstances, dissolves so slowly as to produce a scarcely noticeable evolution of gas. In consequence of the greater insolubility, when magnesium carbonate is present, we would expect those marbles, containing more of it, to weather more slowly than those containing less; and this is doubtless true, except where this advantage is counterbalanced by a structure less suited to resist the mechanical agencies of weathering. G. P. Merrill says:[1]—"The nearer a magnesian limestone approaches a dolomite in constitution, the more durable it is likely to be." On the other hand, it is likely that, under certain circumstances, the grains of dolomite are liable to show a feeble cohesion, favorable to mechanical weathering. Dana says:—"Grains of dolomite are often but slightly coherent." Geikie remarks the same. The accompanying table shows, in the case of the Georgia marbles analyzed, that the dolomitic marbles are fine-grained, while the calcite marbles are coarse in texture. Fineness of grain is an advantage, since it is conducive, somewhat, to strength and durability.

As concerns the influence of accessory minerals, it may be said in general, that it is prejudicial to strength. Mica, in particular, when disposed along certain lines, produces a plane of weakness, owing to the little cohesion along its cleavage planes. On the other hand, a tough, fibrous mineral may, if evenly distributed, contribute somewhat to the strength, acting as a binding material to the granules of calcite.

Extraneous minerals are likewise generally prejudicial to durability. This is sometimes due to the more ready absorption of

[1] Tenth Census; Report on the Building-stones and Statistics of the Quarry Industry.

PLATE XVI.



TOOLS USED IN STONE-CUTTING.

water, in case the foreign mineral is more porous than marble; the water, on freezing, expands powerfully, disintegrates the stone, and gives an easier access to the water. Again, accessory minerals may cause unequal weathering of the marble, thus producing a roughened surface, more favorable to weathering, and very unsightly. The experiments, given below on artificial weathering, show that the smooth polished surface of No. 1 was acted on more slowly than the unpolished cube of the same stone, presumably due, in part, to the greater surface exposed by the rough specimen, and partly to the fact that minute pores, more or less removed in polishing, facilitate chemical action.

The great variety of colors shown by marbles is due mainly to the presence of accessory minerals. Ferric oxide imparts various shades of red. The pink color of No. 6 is due to a very small amount of ferric oxide, in such a fine state of division, that it remains largely suspended in the fluid, when the marble is dissolved in cold dilute hydrochloric acid, a part of it passing through the paper, on filtering. The reddish-brown color of No. 8 is likewise due to ferric oxide in larger quantity, and not so finely divided. Manganese and cobalt may also produce pinkish shades. Iron, when present in the ferrous state in considerable quantity, produces color, varying from light to dark green. The hydrated iron oxides produce a yellowish-brown color. The presence of ferrous carbonate or of pyrite causes the marble to stain yellowish-brown, on weathering, due to the fact, that the compounds named alter readily to a hydrated iron oxide. This staining, in some cases, is said to produoe a very pleasing effect.

The various silicates present will impart to marble their characteristic colors. Organic matter frequently produces a black color, as in marble No 10, which turns white on heating, the organic matter being decomposed and driven off. Graphite likewise produces a black color, the black portions of No. 3 ("Creole") being nearly altogether due to graphite. The black color due to this mineral does not disappear on heating, as it is only very slowly oxidized in the air.

As an experiment to determine the coloring matter in the Creole

marble, a fragment was placed in dilute hydrochloric acid and allowed to stand, until all the calcium carbonate was dissolved. There remained only a tuft of foliated graphite. Other minerals, such as black hornblende and black mica, occur in this marble somewhat sparingly; but graphite seems to be the mineral, which gives the marble its mottled appearance. The same is probably true of the Etowah marble, which occurs close to the Creole.

These various colored minerals, present in varying amounts, are variously distributed, and give rise to an almost endless variety of colors, shades and patterns in the different marbles.

The column in the accompanying table, headed "Insoluble Siliceous Matter," includes all substances insoluble in hydrochloric acid, mainly silicates and silica, as well as silica from any decomposed silicates.

"Loss on Ignition" is mainly carbon dioxide and water; the latter was determined in three or four cases, after drying at 105° to 110° C., and was found to be present to the extent of from three to five per cent. The amount of iron and organic matter was too small to seriously influence the loss on ignition. The iron of No. 8 is mainly ferric oxide, which is not modified by igniting.

It is noticeable that, even if all the loss is reckoned as carbon dioxide there is not sufficient to combine with the calcium and magnesium oxides. This was not due to the oxides being partly in combination with other acids, as these were not present in sufficient quantity. It is certainly partly due to the difficulty of weighing calcium oxide, in which form the calcium was determined. When freshly ignited, it increases quite rapidly in weight, in the desiccator, over concentrated sulphuric acid. However, it seems hardly probable, that this error would be large enough to account for the whole excess.

The following artificial weathering tests were made on unpolished cubes of Nos. 1, 3 and 6 and a polished cube of No. 1. They were suspended for several days in an atmosphere of hydrochloric, sulphurous and carbonic acids:—

	Original Weight.	Final Weight.	Loss.
No. 1. Polished..........	45.0868 grammes.	44.9337 grammes.	.1531 grammes.
No. 1. Unpolished......	45.9492 grammes.	45.7793 grammes.	.1699 grammes.
No. 8. Unpolished......	44.2569 grammes.	44.1240 grammes.	.1329 grammes.
No. 6. Unpolished......	42.1369 grammes.	41.9943 grammes.	.1426 grammes.

It is noticeable that the unpolished cube of No. 1 was dissolved with considerable more readiness than the polished.

CHEMICAL ANALYSES.

Marbles.	Calcium Oxide.	Magnesium Oxide.	Ferric Oxide and Alumina.	Insoluble Siliceous Matter.	Loss on Ignition.	Total.
No. 1...........	54.06%	.90%	.10%	2.12%	42.86%	100.04%
No. 2...........	32.73	19.37	.35	.73	46.58	99.76
No. 3...........	55.00	1.12	.15	.35	44.16	100.76
No. 4...........	31.53	21.30	.24	.10	47.26	100.43
No. 5...........	31.61	21.06	.78	1.01	46.49	100.95
No. 6...........	54.41	.75	.32	1.62	43.13	100.23
No. 7...........	54.67	1.01	.42	.76	43.49	100.35
No. 8...........	[illegible]	.82	3.28	1.43	41.85	100.15
No. 9...........	[illegible]	[illegible]	.43	21.76	37.08	100.58
[illegible]	[illegible]	[illegible]	.91	4.23	Undetermined.	....
[illegible]	[illegible]	[illegible]	[illegible]	[illegible].73		....

[illegible] quarry (Geor-
[illegible]

No. 4. A fine-grained, [illegible]
No. 5. A fine-grained, bluish-[illegible]
No. 6. A coarse-grained flesh-colored [illegible] quarries.
No. 7. A coarse-grained, gray marble, from the Eslinger farm.
No. 8. A coarse-grained, brown marble, from the Haskins farm.
No. 9. A fine-grained, light-gray marble, from the White property.
No. 10. A fine-grained black marble from Six Mile Station.
No. 11. A fine-grained white marble, from Fannin county.

APPENDIX.

A LIST OF SOME OF THE MORE IMPORTANT STRUCTURES IN WHICH THE GEORGIA MARBLES HAVE BEEN USED.

LOCATION.	STRUCTURE.	EXTENT USED.
Boston, Mass	U. S. Government building	4,000 tiles.
Knoxville, Tenn	Episcopal church	Entire building.
Chattanooga, Tenn	U. S. Custom house	Interior finish.
Chattanooga, Tenn	F. F. Marvill building	Marble front.
Macon, Ga	R. E. Park's building	Marble front.
Macon, Ga	Coleman & Willingham estate	Marble front.
Macon, Ga	T. C. Bank's building	Marble trimmings.
Macon, Ga	Edward Wolff's building	Marble front.
Macon, Ga	I. O. O. F. building	Marble trimmings.
Rome, Ga	Floyd county courthouse	Marble basement.
Jacksonville, Fla	U. S. Government building	Entire building.
Atlanta, Ga	Equitable building	2 stories entire, tiles and stairs.
Atlanta, Ga	DeGive's Grand Opera-house	2 stories, floors and wainscoting.
Atlanta, Ga	Aragon hotel	1 story, floors and wainscoting.
Atlanta, Ga	Kimball house	5,000 square feet of tiling etc.
Atlanta, Ga	Gould residence	Exterior walls.
Atlanta, Ga	J. M. High's building	Exterior walls.
Atlanta, Ga	Jas. L. Dickey's building	Marble front.
Atlanta, Ga	State capitol	50,000 tiles, stairs and wainscoting.
Atlanta, Ga	Kutz's building	Marble front.
Atlanta, Ga	Home for the Friendless	Basement and trimmings.
Atlanta, Ga	Southern Medical College	2 stories and trimmings.
Atlanta, Ga	Grant & Kirkpatrick building	Marble trimmings.
Atlanta, Ga	Walker Inman building	Marble front.
Americus, Ga	Bank and Post-office building	Marble front.
Americus, Ga	G. W. Glover's residence	Marble trimmings.
Americus, Ga	Thornton Wheatley building	Marble trimmings.
Nashville, Tenn	Phillips & Buttoff building	Marble front.
Canton, Ga	Bank of Canton	Marble front.
Buford, Ga	Bank of Buford	Marble front.
Elberton, Ga	Elberton Bank	Marble front.
Louisville, Ga	Louisville Bank	Marble front.
Perry, Ga	Masonic hall	Marble trimmings.
Jacksonville, Fla	W. S. Wear's residence	Marble trimmings.
Jacksonville, Fla	J. J. Green's residence	Entire building.
New Orleans, La	Greenwald hotel	Entire trimmings.
New Orleans, La	St. Paul's P. E. church	6,500 feet of tiling and wainscoting.
New Orleans, La	Cosmopolitan hotel	Interior finish.

LOCATION.	STRUCTURE.	EXTENT USED.
New Orleans, La	Kaf T. Hall's store building	Marble front.
New Orleans, La	E. G. Wear's residence	Marble front.
Newark, N. J	Hunt residence	Marble front.
Newark, N. J.	—— church	Trimmings and inside work.
Pittsburg, Pa	Shield's chapel	Entire building.
Savannah, Ga	De Soto hotel	9,000 feet of tiling.
Savannah, Ga	Chatham county courthouse	8,000 feet of tiling.
Birmingham, Ala	Caldwell hotel	Trimmings and interior finish.
Chicago, Ill	D. K. Kill's residence, 24th street	Entire building.
Chicago, Ill.	Nelson Morison's residence, 45th St	Entire building.
Chicago, Ill	Wellington hotel	6,000 feet of tiling.
North Chicago, Ill	Residence, 420 N. State St	Entire building.
North Chicago, Ill	Windemere hotel	15,000 feet of tiling.
North Chicago, Ill	L. G. Well's building	Entire building.
North Chicago, Ill	The Auditorium	40,000 feet of wainscoting.
North Chicago, Ill	Menoken club-house	Marble trimmings.
North Chicago, Ill	Peacock Café, Madison St	Interior finish.
New York, N. Y	Criminal court building	Interior finish.
New York, N. Y	St. Luke's hospital	Entire building.
Brooklyn, N. Y.	St. Cecilia's church	Entire building.
Columbia, S. C	State capitol	40,000 feet of tiling and base.
Sioux City, Iowa	Fox building	12,000 feet of tiling.
Fort Worth, Texas	Courthouse	10,000 feet of tiling.
Fort Worth, Texas	Hendrick's building	12,000 feet of tiling.
Stephenson, Texas	Earth county courthouse	15,000 ft. of tiling etc.
Los Angeles, Cal	Hall of Records	20,000 feet of tiling.
Los Angeles, Cal	Library building	12,000 feet of tiling.
Portland, Ore	Depot building	5,000 feet of tiling.
Providence, R. I	Industrial building	25,000 feet of tiling and base.
Richmond, Va	Chamber of Commerce	5,000 feet of wainscoting.
Sherman, Texas.	Linz building	5,500 feet of tiling and wainscoting.
Pittsburg, Pa	Carnegie library	25,000 feet of tiling.
Boston, Mass	Ames building, Bedford St	Outside trimmings.
Boston, Mass	Boston public library	Arcade and court.
Boston, Mass	Ames building, Court St	Interior toilet-room work.
Waverly, Mass	McLean Asylum	Outside trimmings.
Providence, R. I	Industrial Trust Co.'s building	Interior finish etc.
Detroit, Mich	Pingree building	Exterior of 3 stories.
Exeter, N. H	Saule hall	Interior finish.
Washington, D. C	Congressional library	100 carloads.
Philadelphia, Pa	Drexel Institute	Interior finish.
Tampa, Fla	First National bank	Interior finish.

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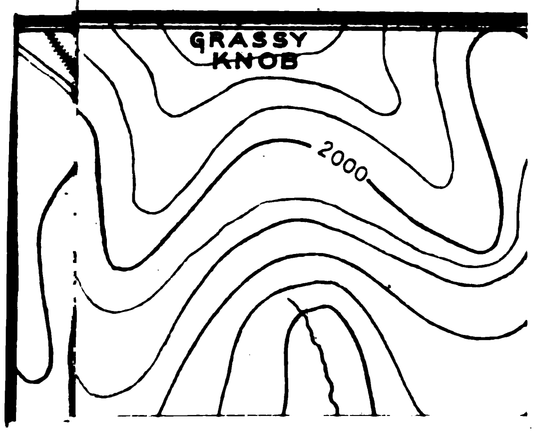
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GEOLOGICAL SURVEY OF GEORGIA

W. S. YEATES, State Geologist

BULLETIN No. 2

A

Preliminary Report

on the

Corundum

DEPOSITS

OF

GEORGIA

BY

FRANCIS P. KING

Assistant Geologist

1894

GEO. W. HARRISON, State Printer

Atlanta, Ga.

With the Compliments of

W. S. Yeates,

State Geologist.

PLATE I. FRONTISPIECE.

LAUREL CREEK CORUNDUM MINES, RABUN COUNTY, GEORGIA.

GEOLOGICAL SURVEY OF GEORGIA

W. S. YEATES, State Geologist

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ON THE

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OF

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FRANCIS P. KING

Assistant Geologist

1894

ATLANTA, GA.
THE FRANKLIN PRINTING AND PUBLISHING CO.
GEO. W. HARRISON State Printer, Manager

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STATE OF GEORGIA, GEOLOGICAL SURVEY,
ATLANTA, Sept. 15, 1894.

To His Excellency, W. J. Northen, Governor, and President of the Advisory Board of the Geological Survey of Georgia,

SIR:—I have the honor to transmit, herewith, the report of Mr. Francis P. King, Assistant Geologist, on the Corundum Deposits of Georgia.

The importance of corundum in the arts, and the high price it commands, should make this report of special interest, Georgia ranking second in the Union, in its production. It is hoped, that this publication will act as a stimulus to the discovery, in Georgia, of other deposits of this valuable mineral.

Like the report on the "Marbles of Georgia," this bulletin is preliminary to a final general report, in which it will be incorporated, with such additional information, as we may be able to get, bringing the subject up to date.

Very respectfully yours,
W. S. YEATES,
State Geologist.

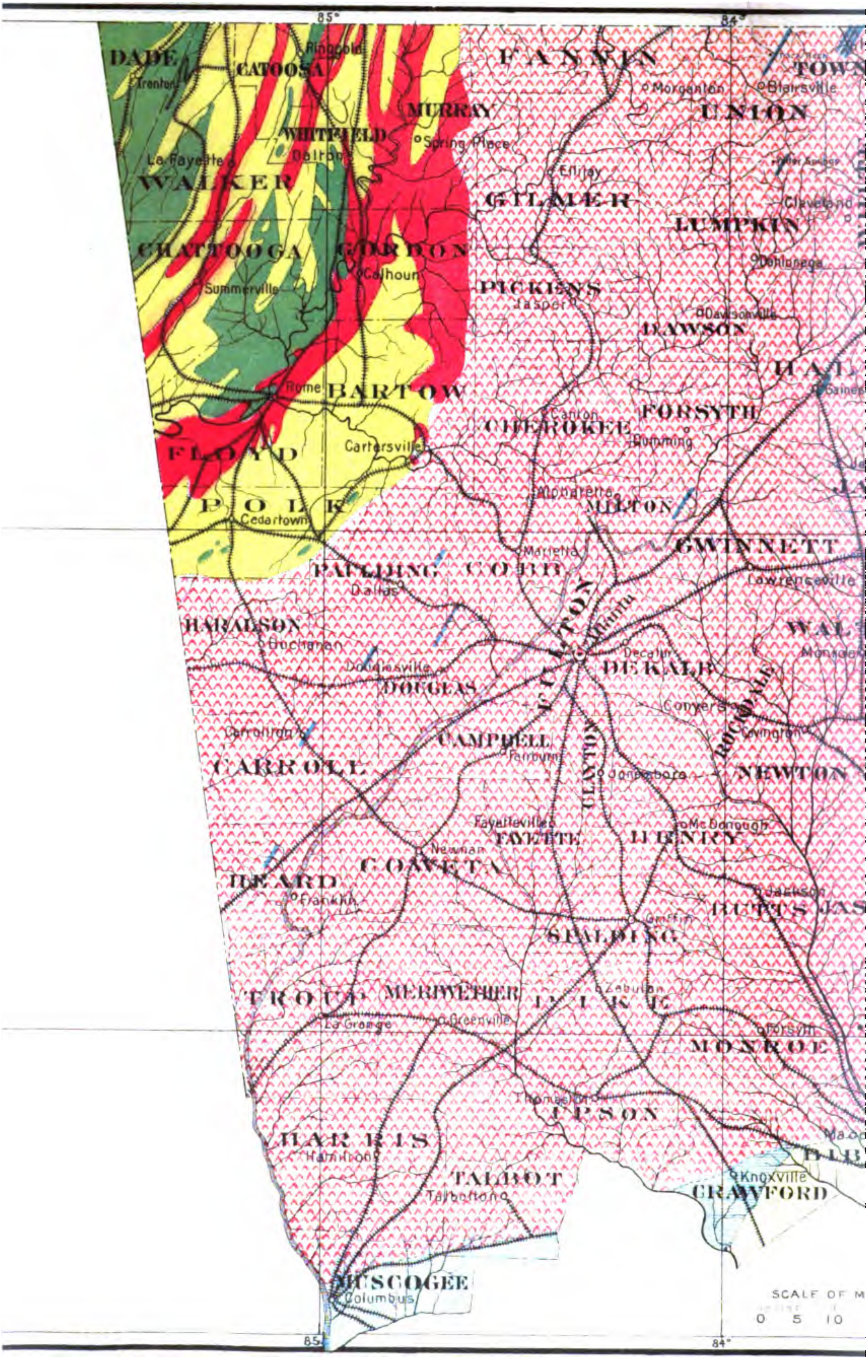
PREFACE.

The subject-matter of this report, it is hoped, is of a nature, to fill a want, continually expressed to the Survey, by citizens interested in this special line of work. In its presentation, with this expression of need in mind, technicalities have been avoided, in so far as scientific treatment would permit, and many features have been elaborated; in other words, an attempt has been made to harmonize scientific accuracy and practical usefulness, by introducing such material, and presenting all, in such a manner, that the report will be both serviceable and easily intelligible to the average reader.

Several of the chemical analyses, which appear in this volume, were made in the laboratory of the Survey by Dr. William H. Emerson, Professor of Chemistry in the Georgia School of Technology. His careful and admirable work speaks for itself.

In conclusion, I desire to express my obligations to the State Geologist for many favors; also, to many citizens of the State for their assistance and hospitality. Space will not permit the enumeration of all these; but I would mention in particular, Mr. Thomas S. Bean of Clarkesville, Mrs. H. A. Burdick, Manager of the Laurel Creek Corundum Mine, Pine Mountain, Rabun Co., Ga., Mr. Corn of Visage, Mr. William R. McConnell and Mr. O. C. Wyly of Hiawassee, Mr. John McConnell of Gainesville, Mr. R. J. Cook of Track Rock, Prof. Leon P. Smith of La Grange, and Dr. E. D. Little of Sheltonville.

Sept. 15, 1894. F. P. K.



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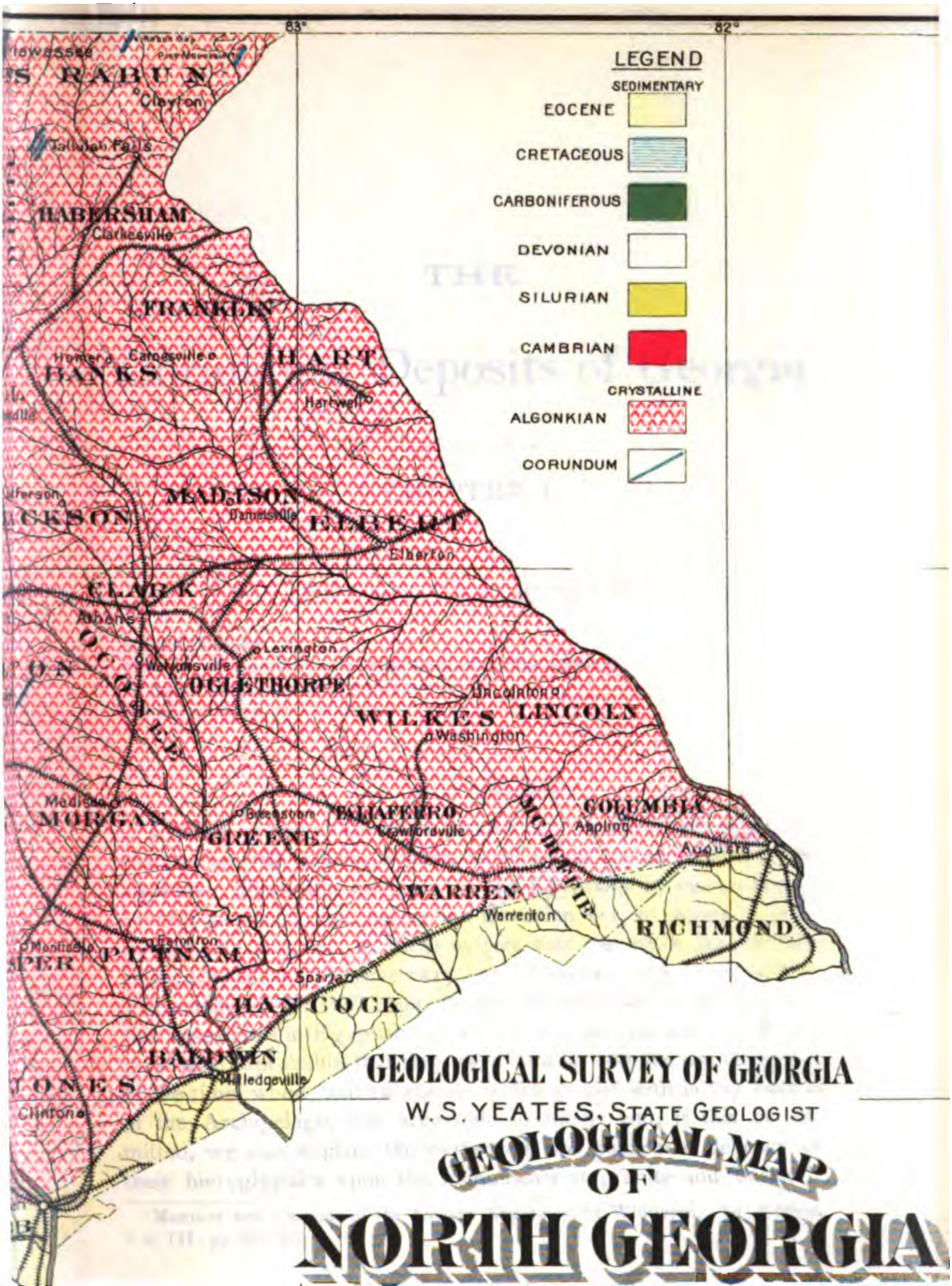


GEOLOGICAL SURVEY OF GEORGIA

W. S. YEATES, STATE GEOLOGIST

GEOLOGICAL MAP OF NORTH GEORGIA

TO ACCOMPANY A PRELIMINARY REPORT ON THE CORUNDUM DEPOSITS OF GEORGIA

BY FRANCIS P KING, ASST GEOLOGIST

1894

THE

Corundum Deposits of Georgia

CHAPTER I.

HISTORY OF CORUNDUM.

EARLY HISTORY.
HISTORY OF CORUNDUM IN THE EASTERN HEMISPHERE.
HISTORY OF CORUNDUM IN AMERICA.
NOMENCLATURE OF CORUNDUM.

EARLY HISTORY.

Little is known of the early history of corundum, although speculations are rife among writers, dwelling on the handiwork of the ancients. Thus, the dexterity of the Egyptians in stone-carving, several thousand years before the Christian era, as shown by their monuments, suggests to these writers, that the work was accomplished by means of some very hard abrasive, such as corundum. For example, Mr. Wilkinson, the English antiquarian, whose scientific researches in Egyptian history are well known, writes:—"It is in no wise improbable, that they were familiar with the use of emery, at the time, when that substance, which is met with in the islands of the Archipelago, was accessible to them; and, if this be admitted, we can explain the perfection and admirable delicacy of their hieroglyphics upon the monuments of granite and basalt."[1]

[1] Manners and Customs of the Ancient Egyptians, by Wilkinson. 1st Edition, Vol. III., pp. 250–257.

More authentic knowledge of the ancients' acquaintance with corundum is confined to the gems of corundum. That they appreciated their value, and sought them as eagerly as we, may be fully understood, when we learn that they regarded the ruby as the very type of all, that is most precious in the natural world. Moreover, we know that the desire to possess, led men to seek them in foreign lands in the time of Solomon. In the Bible, we find the gems of corundum mentioned quite frequently. In Exodus, chapter xxviii, we learn that the breastplate, which God commanded the people to make for Aaron, was to contain, among the twelve precious stones, a carbuncle[2] and a sapphire. Ezekiel tells us, that the king of Tyre had as a covering, among other precious stones, both the ruby and the sapphire. John, in Revelations, describes the foundations of the walls of the heavenly city, as being "garnished with all manner of precious stones," among which were the gems of corundum.

The early Greek writers teem with descriptions and allusions to these gems. From these, we learn that they engraved and cut them, long before the Christian era, and that, in Egypt, they were worked as Scariabean gems. From such writers, also, we learn that the ancients believed the occurrence of precious stones to be confined to certain climates, and "were wont to ascribe the preëminence of certain regions to evaporation from the earth, in which precious stones are found, an evaporation obviously more intense in tropical countries. It was a supposition, pardonably fanciful, that the sunburnt tropics were more favorable to the blossoms of the organic world, than the dark skies of the north."[3] Naturally, to stones so rare and possessed of such wonderful beauty, the ancients attached miraculous power, increasing inestimably their preciousness. It is unnecessary, perhaps, to say that these ancient superstitions have not been entirely effaced; and to-day people may be found, who still give credence to these ancient beliefs. This superstition, particularly, makes the ancient writers' mention of them so fanciful and obscure, that we are often left in doubt, as to real name of the stones.

[2] There is little doubt among authorities, but that the Greek word *anthrax*, here translated carbuncle, is the corundum gem, ruby.

[3] Edwin W. Streeter; Precious Stones and Gems; 3rd Edition, p. 7.

We find, nevertheless, certain writings of the Greeks, as far back as the sixth century B. C., which indicate a considerable knowledge of the physical properties of these gems. In the fifth century B. C., the writings of the Greeks begin to show special acumen in the description of minerals, as seen in the writings of Aristotle and his pupil, Theophrastus, the latter writing an excellent treatise on mineralogy.

Roman succession to the treasure-field marked an increase in mineralogical knowledge and a fuller acquaintance with the characteristics of these gems. Pliny, especially, seems to be well informed, as to where the precious ruby and sapphire occur, and his descriptions of them are sharp and observant. Passing into the Christian era, writers on mineralogy increase, and the subject is developed into a science; but the superstitious legend of the past continued more or less gospel, and precious stones were still worshipped, worn as amulets etc. The twelve apostles were represented by gems called Apostle Stones; and thus the beautiful blue sapphire became emblematic of the heavenly faith of Andrew.

HISTORY OF CORUNDUM IN THE EASTERN HEMISPHERE.

The first known occurrence of corundum is the emery of the Grecian Islands. It is supposed that the early Egyptians obtained emery from this point, and made considerable use of it in the arts. Indeed, up to the time of the discovery of emery in Asia Minor, in 1847, by Dr. J. Lawrence Smith, of Louisville, Ky., it was exported exclusively from these islands, principally from the Island of Naxos in the Grecian Archipelago. The owners of these mines completely controlled the price of emery, and were selling their product at from forty to fifty dollars per ton. At the time Dr. Smith, in the employ of the Turkish Government, made his important discovery, these mines had been purchased from the Greek Government, by an English merchant, and the price had advanced to one hundred and forty dollars per ton. This new discovery reduced the price, writes Dr. Smith in 1850, to fifty and seventy dollars a ton according to quality. The importance of this discovery was not appropriated completely by the Turkish Government. Corundum,

formerly of little interest, except in the arts and as a gem, took on a new importance under the able researches of Dr. Smith. Previous to this time, it was known to occur, only in a few localities, while, as to the method of its occurrence, that is, its geological relation, very little was known. In 1850, Dr. Smith presented two papers before the Academy of Science of Paris—to quote his own words[1]—"in which the subject was thoroughly discussed, and, I might say, almost exhausted." If Dr. Smith did not *exhaust* the subject, he at least developed such important facts, in regard to its geological relations and associate minerals, as to urge investigation and the consequent discovery of many new localities, both in the Old and the New World.

The occurrence of corundum in the Eastern Hemisphere according to Dana is as follows:—"The best rubies come from the mines in Upper Burma, north of Mandalay, in an area covering 25 to 29 square miles, of which Magok is the center. Also found in the marble hills of Sagyin, 16 miles north of Mandalay. The rubies occur *in situ* in crystalline limestone; also in the soil of the hillsides, and in gem-bearing gravel. All the crystallized varieties of the species occur here; the spinel-ruby is an associate. A ruby weighing 304 carats is said to have been found here in 1890. Rubies and sapphires have also been reported from other localities, and the massive varieties are common, especially in the crystalline rocks of southern India. Ruby mines have also been worked at Jagdalak, 32 miles east of Kábul, Afghanistan. Some fine sapphires were obtained in 1882 from the Zánskár range of the Kashmir Himalayas, near the village Machel in Padar; and, since then, mining has been carried on there, with some success. Blue sapphires are brought from Ceylon, often as rolled pebbles, but also, as well preserved crystals. Corundum occurs in the Carnatic, on the Malabar coast, on the Chantibun hills in Siam, and elsewhere in the East Indies; also near Canton, China. At St. Gothard, it occurs of a red or blue tinge in dolomite, and near Mozzo in Piedmont, in white compact feldspar. Adamantine spar is met with, in large, coarse, hexagonal pyramids in Gellivara, Sweden.

[1] Dr. J. Lawrence Smith; Emery Mine of Chester; Scientific Researches, p. 42.

Emery is found in large bowlders at Naxos, Nicaria and Samos of the Grecian islands; also in Asia Minor, 12 miles east of Ephesus, near Gumuch-dagh, where it was discovered *in situ* by Dr. J. Lawrence Smith, associated with margarite, chloritoid, pyrite, calcite etc.; and, also, at Kulah, Adulah and Manser, the last, 24 miles north of Smyrna; also, with the nacrite (?) of Cumberland, England. Other localities are in Bohemia, near Petscha, in the Ural, near Ekaterinburg, and in the Ilmen mountains, not far from Miask; in the gold-washings northeast of Zlatoust, as small crystals (called *soimonite* after Senator Soimonov) in barsovite. Corundum, sapphires and, less often, rubies occur in rolled pebbles, in the diamond gravels on the Cudgegong river, at Mudgee and other points in New South Wales."[1]

HISTORY OF CORUNDUM IN NORTH AMERICA.

GENERAL REMARKS.

Authentic history of corundum in America dates back to the early part of this century. Whether or not the Indians knew of its presence, and made use of it, is simply a matter of conjecture. Their presence in the neighborhood of the occurrences in Georgia is everywhere apparent. This is evidenced in the old carvings on rocks, and the presence of incomplete or broken utensils. The soapstone of the formation, because of its ease in working, was especially attractive to them for the making of pipes, vessels etc. In the road a few hundred yards above the works at Track Rock Mine, Union county, Ga., there are several slabs, one of which is remarkably well preserved, bearing most curious hieroglyphics deeply cut into the rock. Some of these can be made out, as tracks of animals, while the others only the imaginative are permitted to interpret.[2]

There can be but little doubt, however, that, during their presence in these localities, the glistening beauty of the blue and red fragments of corundum, scattered through the soil, attracted the watchful eye of the red man, and was soon lovingly adapted to savage finery.

[1] Dana; System of Mineralogy—6th Edition; p. p. 212-213.
[2] See figure 1.

FIG I.

TRACK ROCK, UNION COUNTY, GEORGIA.

The first authentic date to be found, of the discovery of corundum in North America is 1845; it was then discovered in the township of Newlin, Chester county, Pa. Following the discovery of emery at Chester, Mass., however, in 1864, and the knowledge of the subject, disseminated by Dr. J. Lawrence Smith, Professor C. U. Shepard and Professor C. T. Jackson, explorers began traversing the eastern crystalline belt of the United States from Virginia to Alabama. The result of their work confirmed the prophesies of the mineralogists; corundum was found all along the line. Mines were opened up in several States, explorers entered the field, and new localities have been continually added to the list, up to the time of the present writing.

Prominent among the early explorers may be mentioned Rev. C. D. Smith and Colonel C. W. Jencks, of North Carolina, and Dr. H. S. Lucas, of Massachusetts. To these indefatigable workers is undoubtedly due the most credit, for the development of the corundum resources of North Carolina and Georgia.

CANADA.—Little is known of the presence of Corundum in Canada. I am informed by Dr. Adams, of McGill College, Montreal, that it is known to occur only in one locality. The record of this, in the survey report for 1863, is as follows:—" Corundum has been observed in the second lot of the 9th range of Burgess,[1] and in the immediate vicinity of a deposit of copper pyrites. Here, in contact with the crystalline limestone, occurs a rock made up of feldspar, quartz, calcite, silvery-white mica and sphene. Disseminated throughout this aggregate were small grains of a mineral, whose color varies from light rose-red to sapphire-blue, while its hardness, which was greater than that of topaz, showed the mineral to be corundum. Small crystals of light-blue corundum have been found elsewhere in the limestone of the vicinity."[2]

MAINE.—Dana says, that a few crystals of corundum have been found at Greenwood in a mica-schist, with beryl, zircon and lepidolite. With this exception, no record of its occurrence in the State can be found. Dr. W. S. Bayley, Professor of Mineralogy and Geology at Colby University, writes that the locality mentioned by Dana is unknown to the collectors.

MASSACHUSETTS.—Professor C. T. Jackson, on October 22nd, 1863, while surveying an iron mine at Chester, Mass., discovered some veins of margarite, and, from this, "ventured to predict the occurrence of emery."[3] About a year later, he met Dr. Lucas, one of the owners of the mine, and again called his attention to this discovery. "The next day after his return to Chester, he (Dr. Lucas) found the emery, a big vein nearly six feet wide, which had been mistaken by him for iron ore, it being very magnetic."[3] This discovery marks the opening of the industry in America. Mills were erected at Chester, Mass., for the preparation of this mineral for the market; but the emery, mined sometime, was finally found to be too soft for the trade, and has since been abandoned. Later, corundum was mined there.

Professor Shepard found the vein to have an extent of about

[1] A township and a province of Ontario.

[2] Report of Geological Survey of Canada for 1863, page 499.

[3] Scientific Researches; J. Lawrence Smith, page 44.

four miles, and an average width of four feet. It extends through a great gneiss formation, flanked on the east by a mica-slate. Between the mica-slate and the eastern gneiss wall, talcose-slates intrude, averaging from twenty to one hundred feet in thickness. No corundum, emery or magnetic particles have thus far been detected as constituents of the gneiss; but particles of these minerals are scattered throughout the talcose formation. The minerals, associated with the emery vein, are corundum, diaspore, ripidolite, margarite etc.

CONNECTICUT.—Professor George J. Brush has in his collection two specimens of corundum, which were found in this State in 1870. This is approximately the date of the discovery of corundum in Connecticut. Dana reports it from near Litchfield, and at Norwich, with sillimanite, rare. It also occurs at Newton, in Fairfield county.

Professor S. L. Penfield writes me, that the crystals are light pink, presenting the simple combination of short hexagonal prisms of the second order with the basal plane. No work has been done to open up a vein; consequently, the nature of its occurrence is unknown. Professor Penfield thinks it occurs in the crystalline schists, since the crystals of corundum are found embedded in blue kyanite.

NEW YORK.—Corundum was discovered, very early, in this State. It has been found at Warwick and Amity, Orange county, also in Cortlandt Township, Westchester county. The latter locality was described by Professor George H. Williams, in his interesting papers on the "Cortlandt Series." Westchester county, up to last year, when the mining company assigned, was one of the sources of supply to the United States.

NEW JERSEY.—The State Geologist reports, that it was probably first found at Vernon, date unknown. A prolongation of the New York dolomitic limestone, bearing corundum, at Franklin, Newton and Vernon, furnish isolated pockets of blue and red corundum. In Sussex county, it occurs in the gneissoid rock. No economic work on corundum has been done in this State.

MARYLAND.—Tyson reports the occurrence of corundum near White Hall. Considerable work had been done here on magnetic iron and copper ore, in the magnesian belt, previous to the civil war; and, since then, several geologists have examined the locality for corundum, but without success.

PENNSYLVANIA.—In 1845 some large masses of corundum were found on the surface; and later it was mined in Newlin township, Chester county. This is probably the first discovery of corundum in Pennsylvania. A paper on the minerals in the vicinity of Philadelphia, by Dr. Isaac Lea, in the proceedings of the Academy of Natural Sciences, 1818, does not mention corundum, although the writer had explored, to a great extent, Chester and Delaware counties. Following the discovery of corundum in 1845 at Newlin, it was found commencing near Blue Hill, in Upper Providence Township, and extending for about five miles to near Rockdale, Middletown Township, Delaware county, and again appearing near Unionville, in Newlin Township, Chester county. Mr. T. D. Rand, of Philadelphia, who has kindly supplied me with information on the history of corundum in Pennsylvania, says that a locality in Lehigh county shows no indication of serpentine, as at the other localities, but that the corundum occurs chiefly in large, loose crystals in a granitic or syenitic rock. The deposit in Chester county, at the time Dr. Genth wrote Volume B of the Pennsylvania Geological Survey reports, was supposed to be of great extent and value; but the large masses, which characterized the mines soon gave out; and while mining has been continued more or less ever since, the yield has been comparat vely trifling.

VIRGINIA.—The only place in this State, from which corundum has been reported is Bull Mount, Patrick county. Here, in the fall of 1888, Mr. W. B. Rucker, of Stewart, Patrick county, discovered a few specimens of corundum and associate minerals.[1] The region is composed of mica-schist, talcose mica-schists and chloritic slates. Chrysolitic or serpentine rocks have not been observed in the neighborhood. It was thought, therefore, by Dr. F. A. Genth, who described the locality in the *American Journal of Science*, just cited,

[1] Am. Jour. Sc., 3d Series, Vol. XXXIX, p. 47, 1890.

that the corundum, which has only been found on the surface, belongs to several granite dykes, which intersect these schists. The minerals associated with the corundum are kyanite, andalusite, muscovite, margarite and chloritoid.

NORTH CAROLINA.—This State takes the lead in the corundum industry, not only in the number of working mines, but also in the amount of corundum produced. Dr. Genth tells us:—"The first large mass was found in 1847 on the French Broad river, three miles below Marshall, in Madison (then Buncombe) county. It was of dark-blue color, and was associated with chlorite and margarite." In 1870, Rev. C. D. Smith sketched the corundum belt of North Carolina, as "running in a southwesterly course across Macon county, where it strikes the Georgia state-line, its general direction coinciding with the trend of the Blue Ridge, until it reaches the head of the Tennessee river, when it suddenly ceases on encountering the Nantegalee mountain (a spur of the Blue Ridge here running due north), to reappear 10 miles to the northwest on Buck Creek, whence it pursues its original course of northeast and southwest across the Chunkygal mountains, where it again enters the Blue Ridge.[1] Later investigation has revealed a more extended belt.

The last writing on the corundum deposit of the State is by E. W. Parker, in the United States Mineral Resources, 1893, who reports:—"The corundum is found in pockets and veins, usually from four to twelve feet wide, chiefly in gneiss, talc, chlorite and mica-schists, in massive anthophyllite, olivine or serpentinized rocks."

The principal mines are located in Macon, Jackson and Transylvania counties.

GEORGIA.—The gold washers knew of the presence of corundum in Georgia, "early in the forties;" but they paid no attention to it. About 1852, Mr. Plant, banker at Macon, Ga., sent a ruby, a small, red hexagonal prism, to Professor Shepard of Amherst College, which was said to have come from a gold mine in Habersham county, Ga. Similar brief mention, by writers of the period of 1870, place the knowledge of its presence in Georgia, at an early date in

[1] C. U. Shepard, Am. Jour. Sc., 3d Series, Vol. IV, 1872.

the American history of corundum; yet there seems to have been no systematic search made for the mineral, at this time. About 1870, Mr. William R. McConnell, of Hiawassee, Towns county, an enthusiastic explorer, found a considerable quantity of surface corundum on his estate; and, not knowing what it was, he piled it up for later determination. Shortly after, a specimen of this was shown to Rev. C. D. Smith, who immediately recognized it as corundum. About the same time, also, corundum was found by Mr. Thompson at Laurel Creek, Rabun county.

Interest, however, in Georgia occurrences was not fully awakened, until Dr. H. S. Lucas of Massachusetts opened up the Laurel Creek property. Since then, corundum has been searched for, in the northern counties, even by children.

SOUTH CAROLINA.—The corundum, found thus far in South Carolina, has attracted little attention. Its occurrence here is undoubtedly similar to that of North Carolina and Georgia. In the Resources of South Carolina, published in 1883, by the State Board of Agriculture [1], corundum is merely mentioned as a mineral occurring in Laurens, Anderson and Oconee counties in a mica-slate (?).

ALABAMA.—Dr. Eugene A. Smith, State Geologist, in answer to my letter of inquiry concerning the history of corundum in Alabama wrote:—"Corundum was first discovered in Alabama, near Dudleyville in Tallapoosa county about the year '72 or '73. The first notice of it was published by the Rev. C. D. Smith of North Carolina, who was searching for asbestos for a company. It has since been found in the neighborhood of Hanover, Coosa county. The Tallapoosa variety has been found only in loose pieces embedded in the soil, and has, as far as I know, not been found in place, there. It is associated with steatite, hornblendic and pyroxenic rocks, and, also, with tourmaline, asbestos and feldspar. In the Coosa county locality, the corundum appears to be enveloped in a thin coating of talc. Corundum has never been of any economic use in Alabama, principally for the reason, that the original vein has never been exposed, and nothing but more or less altered fragments have been obtained."

[1] South Carolina Resources etc., p. 187, 1883.

MONTANA.—According to Mr. G. B. Foote, one of the pioneers of Helena, corundum in the form of the precious stones, ruby and sapphire, was first discovered at Eldorado Bar, in December, 1865; but the earliest mention of finding sapphires in this State dates back to May 5, 1865, when Mr. E. R. Collins, an earnest and reliable prospector, found them on claim No. 4. Dr J. L. Smith called attention to this discovery in the *American Journal of Science*, in September, 1873.

The gems were discovered in the sluice boxes of the placer mines. In a short time, after having determined the limits of the precious stone bearing sands, a company was formed in London, under the title, "The Sapphire and Ruby Company of Montana, Limited," and the country was worked for both alluvial gold and precious stones. Since this time, the Montana fields have increased somewhat in importance, and are now recognized by the trade, as one of the sources for sapphires of medium grade, no true red rubies or true blue sapphires having been found. The rocks in the vicinity are limestone, quartzite and dark argillaceous slates. These are broken through and intersected by dykes, some of which have been described as mica-augite-andesite. In these dykes are found well defined crystals and rounded masses of sapphires, and other minerals. This, then, is the probable source of the innumerable sapphires, found in the alluvial deposits.

COLORADO.—Corundum was first found in this State in 1882, at the Calumet iron mines, situated in Chaffee county; this is the only locality known at present. It is found in small tabular crystals, mostly blue, though some are white. The crystals show the basal planes and rhombohedral faces, only; no prisms have been observed, in any instance. It occurs in siliceous and micaceous-schists, in which appear occasional pegmatitic bands. This has been metamorphosed, by intrusions of diorite. The associated minerals are quartz, feldspar, yellow mica, a little rutile and grains of magnetite. Mr. R. C. Hill, Geologist of the Colorado Fuel and Iron Company, Denver, to whom I am indebted for the information, says, that the "ore" is bunchy; but there seems to be a large quantity of it, the excavation showing it to extend one thousand feet on the outcrop.

At the time he wrote, they were having a car-load put through the concentrating mill, with a view to finding out what could be done with it.

CALIFORNIA.—No mention is made of corundum in the reports of the State Mineralogist. Dana, however, reports it, in Los Angeles county, in the drift of San Francisqueto Pass. Personal letters, from several of the leading mineralogists in the State, contain the same reply:—"The only knowledge we have of the occurrence of corundum in California is that, given in *Dana's System of Mineralogy.*" It is evidently very rare.

NOMENCLATURE OF CORUNDUM.

The terms applied to the varieties of corundum are various, and have been much confused. This is accounted for, not only by the very early knowledge of this mineral, but, principally, from the fact, that only in the early part of this century were these varieties united under one head. Dr. Thomas Egleston,[1] of the School of Mines, Columbia College, has tabulated the following list of terms found in literature, past and present:—

CORUNDUM.

Adamant, *Kirwan.*	Demantspath, *Klaproth.*
Adamantine spar, *Phillips.*	Diamond spar.
Adamas siderites, *Pliny.*	Gyrasole, *Kirwan.*
Alumina.	Imperfect corundum, *Greville and Bournon.*
Anthrax.	Karund, *Hind.*
Corindon, *Hauy.*	Korund, *Werner.*
Corindon Adamantine, *Brongniart.*	Rhombohedral corundum, *James.*
Corindon Harmophane, *Hauy.*	Rhombohedrischer corund, *Mohs.*
Corivendum.	Solmonite.
Corivendum, *Woodward.*	Spath adamantine, *Delam.*
Corundite.	Thoneride.

[1] Catalogue of Minerals and Synonyms, by T. Egleston.

Sapphire.

Hyacinthos, *Greek.*
Anthrax, Theophrastus.
Amethyste orientale.
Apyrote.
Asteria, *Pliny.*
Asteriated sapphire.
Asterie.
Barklyite.
Blue du roi.
Blue sapphire.
Carbunculus.
Cat sapphire.
Corindon harmophane.
Corindon hyalin, *Hauy.*
Corindon perfect.
Corindon telesie, *Brongniart.*
Emeraude orientale.
Hyacinth.
Hyacinthos.
Lichnis, *Pliny.*
Luchs saphir.
Luchs sapphire.
Lynx sapphire.
Opalescent sapphire.
Oriental amethyst.
Oriental aquamarine.
Oriental chrysolite.
Oriental emerald.
Oriental hyacinthe.
Oriental persodot.
Orientel ruby.
Oriental sapphire.
Oriental topaz.
Orientalisk rubin, *Wallerius*
Rubie etoile.
Rubin.
Rubis.
Rubis oriental, salamstein, *Werner.*
Salamstone.
Saphir, *Werner.*
Saphir asterie.
Saphir blanc.
Saphir de chat.
Saphir etoile.
Saphir.

Emery.

Acone ex Armenias, Theophrastus.
Smiris.
Dioscorides.
Armenian Whetstone.
Corindon granuleux, *Hauy.*
Emeri.
Emeril, *Hauy.*
Emerite, *Shepard.*
Fer oxyde quartzifere, *Hauy.*
Granular Corundum.
Grinding spar.
Naxium.
Naxium ex Armenia.
Pyrites vivus, *Pliny.*
Schmergel.
Schmirgel.
Smiris, *Agricola.*
Smiris ferrea, *Wallerius.*
Smiris.

CHAPTER II.

VARIETIES OF CORUNDUM.

INTRODUCTORY REMARKS.
SAPPHIRE.
CORUNDUM.
EMERY.
PHYSICAL PROPERTIES.
ARTIFICIAL PRODUCTS.

INTRODUCTORY REMARKS.

When the oxide of aluminum is found in the native state, it is known as corundum. The name corundum is derived from the Hindoo word *Kurand* (corundum stone)—corundum being probably first known in Europe from the Indian import. Three varieties of corundum are recognized, viz.: —

1. Sapphire,
2. Corundum,
3. Emery.

This classification was adopted early in the century, and the same is recognized in the arts to-day. Previous to this time, owing to differences in color, hardness, degree of transparency, and state of crystallization or structure, they were considered as distinct species. In 1805, they were united under one head by Hauy, although relationship of species in crystallization had been observed by the early crystallographer, Romé de Lisle.

The oxide of aluminum in its purest state is perfectly colorless and transparent; but it is seldom found in this condition ; corundum is generally tainted by some oxide of metal. The purer kinds of fine colors, transparent and translucent and useful as gems, are known as *sapphires;* the dull colors, not transparent, are called *corundum;* while the black or grayish-black variety intimately

mixed with oxide of iron, either magnetite or hematite, is distinguished as *emery*.

SAPPHIRE.

The variety termed "Sapphire" includes all those kinds of corundum, which, on account of their purity in color, transparency and translucency, may be used as gems. Under this head, therefore, are grouped many stones having individual names. For simplicity in classification, jewelers have adopted the following table. It will be observed in this table that shades of red are classified as "Rubies," while any other color, or those destitute of color, pass under the head of "Sapphire": —

JEWELER'S CLASSIFICATION OF SAPPHIRE.

SAPPHIRE.		RUBY.	
True Sapphire	blue.	True Ruby or Oriental Ruby	red.
Sapphire	shades of blue.	Anthrax (Theophrastus)	
SAPPHIRE,		Carbunculus	
(Diamond Spar)	white.	Lychnis (Pliny)	
(Adamas, Pliny)		Ruby	shades of red.
Oriental Topaz	yellow.	Oriental Amethyst	purple.
Oriental Emerald	green.		
STAR SAPPHIRE	Asteria (Pliny).		

RUBY.—This is pre-eminently the most important of the "precious stones" of this species. Its marvelous beauty, which induced worship from the ancients, has ever awakened an allied feeling in the hearts of Christians. Stones of true "pigeon's blood" color are extremely rare and valuable. Burma, Siam and Ceylon are practically the only commercial fields; and, of these, Burma alone has become celebrated for the production of the true color, though occasionally fine gems are found both in Siam and Ceylon. According to Mr. Edwin W. Streeter,[1] their original matrix was probably crystalline limestone, the disintegration of which has left them distributed along the hills and valleys and on the floor of limestone caverns. The typical ruby-bearing earth seems to be a yellowish clay, known locally as *Byon*.

[1] Any one interested in the study of gems will be well repaid to read his admirable work entitled "Precious Stones and Gems," 5th edition, published by George Bell & Sons, Covent Garden, London.

The value of rubies of true color depends largely upon judicious cutting, size and flawlessness. A perfect ruby of one carat weight, or more, has always taken precedence of the diamond in value. Of the two, equally perfect and five carats in weight, the ruby will bring ten times the price of the diamond. Above ten carats, the value of such a ruby is inestimable. This may be better illustrated by a well known sale, in which the rubies were considered to have been sold at a great loss. In 1875, the necessities of the Burmese Government compelled it to sell to the London market two rubies, which connoisseurs pronounced the finest ever seen. They weighed, when recut, one 32 5-16, the other 38 9-16 carats. They were sold for $50,000 and $100,000, respectively.

SAPPHIRE.—The sapphire was ranked by the ancients, almost as high, if it was not held in quite as close esteem, as the ruby. To it, as to the ruby, they ascribed wonderful properties, and prized it exaltedly. As with the ruby, commerce knows only of a few localities, in which it is found in sufficient abundance to pay for mining. These are Siam, Burma, Cashmere and Ceylon, Siam yielding the most beautiful and perfect stones. Owing to large finds, which have been made in the East, within the last fifteen years, the sapphire has greatly depreciated in value, though exceptionally fine stones are still highly prized.

The finest sapphire in the world came from India. It is a richly colored blue stone, and weighed, on arrival in Europe, 225 carats. Owing to a flaw, it was recut into a gem of 165 carats. This was sold in Paris, and was estimated to be worth from $35,000 to $40,000.

STAR SAPPHIRES.—There are certain varieties of corundum, which show a stellate "opalescence," or a star of light, when viewed in the direction of the vertical axis of the crystal. This is especially true of the grayish-blue translucent sapphires. Furthermore, there are purple and reddish shades of ruby, which, when properly cut, also show this asterism. Stones of such character are known as "Star Sapphires."

The optical phenomenon here presented is due to the internal structure of the stone. All star sapphires show the laminated

structure, and, on the basal planes, lines radiating from a common center. The action of the light on these radiating lines gives rise to a star-like opalescence, which is very attractive. Star sapphires have increased in value in the past few years ; but this value is very small, unless they are of finest rank and color. Small star sapphires range from ten dollars upward. The finest star ruby, lately seen in England, was valued at $10,000.

HOW TO SELECT SAPPHIRES.—In the selection of sapphires, one must guard particularly against imperfections ; for the sapphire is typically imperfect. An examination, in person, of a first-class jeweler's collection of sapphires, revealed, out of a hundred stones, only two or three free from defects. The common defects are an imperfect transparency, clouds, spots partially opaque, massing of color at one spot, fine dark lines, white glassy stripes, rents, knots and silky flakes on the table of the stone. These defects are frequently observable to the naked eye ; but their presence is rendered more evident by the use of a lens. An expert gem-cutter will so cut a sapphire, with its color massed at one spot, as to cause the color to be dispersed by the reflection of the light against the facets. The color of the sapphire is often merely a matter of taste ; yet, to the trade, color is most important, and "true colors" are recognized. The most valuable ruby has the color of "pigeon's blood," while the true sapphire must have the characteristic velvety appearance of the blossom of the little "corn flower."

CORUNDUM.

The variety, corundum, includes all semi-transparent and translucent kinds of corundum, not useful as gems; also, all the dull and opaque kinds, except emery. Three types are commonly distinguished in mines, viz: —

1. Sand-Corundum.
2. Block-Corundum.
3. Crystal-Corundum.

SAND-CORUNDUM.—This is a granular corundum, coarse or fine, usually found embedded in a gangue of vermiculites or of decom-

posed feldspar. In some veins, it occurs free, while in others, alteration or associate minerals, commonly albite, margarite or damourite (a variety of muscovite), wrap it closely, forming a crust, which frequent washing will not remove; a machine for the purpose is required. Sometimes, it is penetrated by vermiculite scales. The color of sand-corundum is usually gray to grayish-blue, although red is common, and all the other colors may be detected. This is much the most productive of corundum found, and, therefore, the most worked. Moreover, veins of this character seem universally present in corundum mines.

BLOCK-CORUNDUM.—This includes the massive corundum with nearly rectangular parting or pseudo-cleavage. The largest specimen of this kind, known to have been found, was taken from the Laurel Creek mine, Rabun county, Ga., and was said to weigh over 5,000 pounds; other immense blocks have been taken from the same mine, on account of which the mine is frequently called a "block-corundum mine." Veins, however, of this character, that is, in which the corundum is massed in such large bodies, although extremely rich at times, are usually abandoned as non-paying.

CRYSTAL-CORUNDUM.—Crystal corundum is quite common, and includes all corundum possessing crystal form. It is present, with both the sand and the block-corundum, and ranges in size from very minute crystals to those of magnificent proportion. Among the largest crystals ever found were some, which were taken from the so-called block-corundum veins at Laurel Creek mine, during the summer of 1893; they are now in the possession of Dr. H. S. Lucas. A description of these is given with figure 2. Corundum crystals are usually rough, and seldom transparent; this is especially true of large crystals. Frequently, moreover, the large crystals do not possess a uniform color; but patches of gray, blue and red tints blend into each other. The most common type in Georgia and North Carolina are six-sided prisms, usually with the basal plane, and quite frequently terminated by a pyramid. Fuller particulars on these types will be omitted, to avoid repetition, later.

FIG. 2.

1 2

Large Corundum Crystals from the Laurel Creek Corundum Mines, Rabun County, Georgia. 1. Height, 14 inches, diameter, 8½ inches. 2. Height, 16 inches.

EMERY.

Emery is an intimate mixture of corundum and magnetite or hematite. It is without crystal form, and has the appearance of a fine grained iron ore, which it was thought to be, for some time. Its hardness is due to the presence of corundum; and this, together with its abundance, makes it very desirable as an abrasive agent. Emery has been supplied to the world many years from the Grecian islands, where it has been known and used, for thousands of years. Here it is found in a bluish metamorphic marble, interbedded with mica-slate and gneiss. Its occurrence is in the form of nodules and large irregular masses, some of which are several yards in diameter and up to forty tons in weight. These large pieces, unless fissured, are broken with great difficulty, on account of the compactness of the grain. Since the transportation from the quarries is only on the backs of horses and camels, those masses which will not yield to the hammer are exposed to the action of fire for several hours, and are thus broken up. Dr. J. Lawrence Smith's investigations for the Turkish Government, and his discoveries of 1847, so increased the known area of emery in that region,

that the monopoly, exercised by the owners of the Greek property, was completely broken, and the price was reduced more than one-third. Following Dr. Smith's discoveries, and consequent, in a great measure, upon his able reports on the geological relations, emery was discovered in other parts of the world. In the United States, in 1863, Professor Jackson discovered a vein of emery at Chester, Mass.[1] The greater portion of emery, however, used in this country comes from the Grecian islands, and is known to the trade as Naxos emery or Turkish emery. "For the decade ending with 1878, our average annual import of emery ore was 2,376,743 pounds. For the decade ending with 1888, it was 7,315,165 pounds, the year 1888 showing the largest total of any year but one, during twenty years. That total was 9,643,800 pounds. While the annual import of ore was more than tripled in the second decade, the annual average import of granulated and pulverized emery slightly decreased. That annual average import was for the first decade 621,807 pounds, and for the last, 589,054 pounds. The total annual average import of ore and grain for the first decade was 1,338 tons, and for the second, 3,521 tons."[2] It will be seen, by table on page 113, that the increase has been, on the average, continuous up to date.

Very little emery has thus far been found in North Carolina, and none in Georgia. In 1893,[3] emery was discovered on Skeena creek, five miles from Franklin, Macon county, North Carolina. The abundance of the deposit has not been reported.

PHYSICAL AND CHEMICAL PROPERTIES.

CHEMICAL COMPOSITION.—The formula for corundum is written Al_2O_3. Sapphire and common corundum are considered essentially pure oxides of aluminum, while emery is an intimate mixture of corundum with an oxide of iron, either magnetite or hematite.

[1] See this report, under Massachusetts, p. 15.

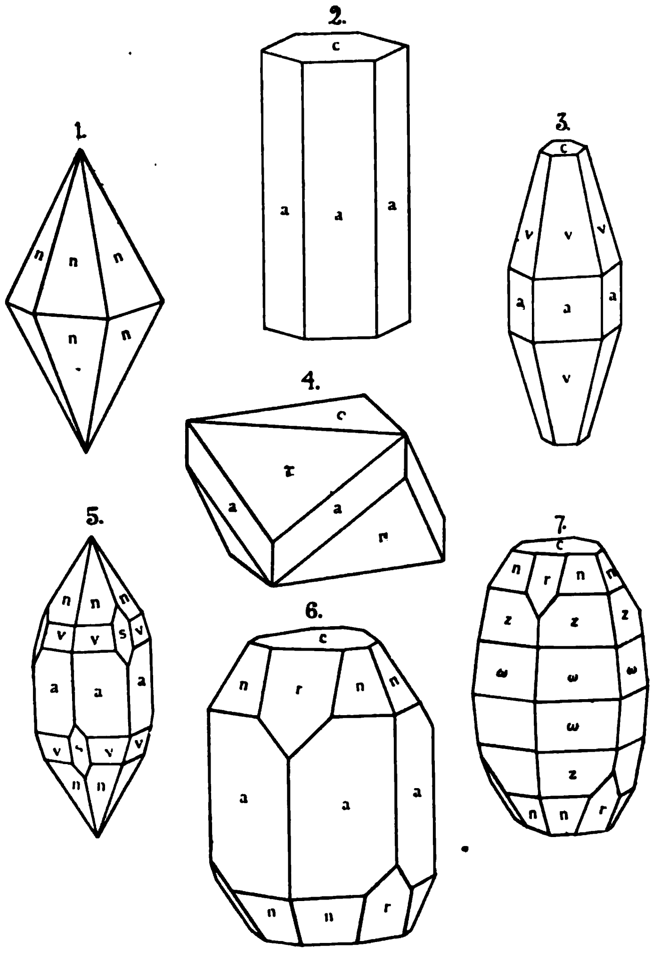
[2] T. Duncan Paret; Journal of the Franklin Institute, March, 1890.

[3] Mineral Resources of the U. S., 1893, p. 675.

Analyses of corundum and emery, made by Dr. J. Lawrence Smith, are as follows:—

No.	LOCALITY.	Effective Hardness. Sapphire, 100.	Specific Gravity.	COMPOSITION. Water.	Alumina.	Magnetic Oxide of Iron.	Lime.	Silica.
	. EMERY.							
1	Kulali........................	57	4.28	1.90	63.50	32.25	0.92	1.61
2	Samos........................	56	3.98	2.10	70.10	22.21	0.62	4.00
3	Nicaria........................	56	3.75	2.53	71.06	20.32	1.40	4.12
4	Kulali	53	4.02	2.36	63.00	30.12	0.50	2.36
5	Naxos........................	46	3.75	4.73	58.53	24.10	0.86	3.10
6	Nicaria	46	3.74	3.10	75.12	12.06	0.72	6.88
7	Naxos........................	44	3.87	5.47	69.46	19.07	2.81	2.41
8	Ephesus........................	42	4.31	5.62	60.10	33.20	0.48	1.80
9	Kulali........................	40	3.89	2.00	61.05	27.15	1.30	9.63
	CORUNDUM.							
1	Sapphire of India.............	100	4.06	....	97.51	1.89	....	0.80
2	Ruby of India................	90	....	....	97.32	1.09	....	1.21
3	Corundum, Nicaria...........	77	3.88	1.60	92.39	1.67	1.12	2.05
4	" Asia Minor........	65	3.92	0.68	87.52	7.50	0.82	2.01
5	" Asia..............	60	3.60	1.66	86.62	8 21	0.70	3.85
6	" India............	58	3.89	2.86	93.12	0.91	1.02	0.96
7	" Asia..............	57	3.80	3.74	87.32	3.12	1.00	2.61
8	" India......	55	3.91	3.10	84.56	7.06	1.20	4.00
	EMERY.							
1	Chester, Mass................	33	....	....	44.01	50.21	....	3.13
2	" "	40	....	....	50.02	44.11	....	3.25
3	" "	39	....	....	51.92	42.25	....	5.46
4	" "	45	....	....	74.22	19.31	....	5.48
5	" "	..	....	....	84.02	9.63	....	4.81

FIG. 8.



CRYSTAL FORMS OF CORUNDUM.

CRYSTAL FORM AND STRUCTURE.[1]—Corundum crystallizes in the Rhombohedral Division of the Hexagonal System. The crystals are usually doubly terminated, six-sided pyramids or six-sided prisms, terminated by the basal plane, and, not unfrequently, they are in tabular crystals or six-sided plates. The pyramidal and prismatic faces are more or less deeply striated or grooved horizontally. The basal planes or truncated ends of the crystals are striated parallel to the edges, or divided into sectors by lines radiating from the center. The latter, when cut *en cabochon*, that is with a convex face simply polished, reflects, from the convex surface, a star of light (asterism). If the crystals are large they are usually rough and rounded. Most specimens found are rolled pieces and fragments. It also occurs massive in coarse and fine grains. Twins occur, either as penetration or polysynthetic forms, most frequently the latter. In both cases, the twinning-plane is the rhombohedron. When the twins are polysynthetic, that is, when the twinning-planes of the aggregate of indíviduals continue parallel to each other, a laminated structure is produced. This structure gives rise to the pseudo-cleavage or parting, so common in corundum.

COHESION.—Cleavage is due to minimum cohesion. In corundum there is no true cleavage, but a pseudo-cleavage, due to parting. Parting should be clearly distinguished from cleavage. Cleavage is the natural fracture along the plane of minimum cohesion or least resistance ; parting is a plane, in which the cohesion is minimum, because the structure is lamellar through twinning, or in which the cohesion has been reduced to a minimum by pressure. Parting in corundum is sometimes perfect, but interrupted, parallel to the basal plane. There is also a parting parallel to the rhombohedron. The former parting is due to pressure, and the latter to twinning.

Corundum is extremely brittle, except when compact; then it is tough. A broken surface shows an uneven to conchoidal fracture.

[1] The best text-book in English on crystallography is published by Henry Holt & Co., New York City, entitled, "Elements of Crystallography," by Dr. George H. Williams, late Professor of Geology at Johns Hopkins University. Those, interested in the collection and study of minerals, and who desire more information on crystal structure, than is commonly found in mineralogies, will do well to provide themselves with this little book.

The hardness of corundum is 9.[1] It will be seen, by the table of analyses made by Dr. Smith,[2] that there is a considerable difference in hardness between different varieties of corundum, and between specimens of the same variety from the same or different localities. This will be considered in the chapter on economics.

SPECIFIC GRAVITY.—The density of corundum, as compared with that of water as a standard, assumed to be 1, varies but slightly from 4. This quantity is not constant, owing to the variations in chemical composition and physical structure.

OPTICAL PROPERTIES.—The luster of emery is metallic, or the luster of metal; of the other varieties of corundum, it is adamantine[3] to vitreous.[4] The color of corundum varies, not only in different localities, but in the same locality—ranging from white to brown, viz., white, gray, blue, red, yellow and brown. Emery is dark-blue to black; its streak is uncolored. Pleochroism, or that property, which certain minerals possess of showing a different color, when light is transmitted through a crystal in different directions, is observed in the deeply colored specimens of sapphire. Spinel and garnet, minerals often confused with sapphire, do not possess this property on account of their crystalline character; and hence, by means of the dichroscope, an instrument so constructed, that the result of light transmitted in two directions may be compared side by side, this

[1] Many minerals, which, to the average observer, resemble each other closely, may be readily distinguished by their hardness. This is especially true of corundum, and minerals bearing a striking resemblance to it. Mohs has made out a table of ten minerals, with which all minerals are now compared. The determination is made by the resistance a smooth surface offers to scratching. It may be well to state, in regard to the following table, that there is a greater difference between corundum and diamond, than between talc and corundum, a break, which we have no known natural minerals to bridge.

MOHS' SCALE OF HARDNESS.

1. Talc.	6. Feldspar.
2. Gypsum.	7. Quartz.
3. Calcite.	8. Topaz.
4. Fluorite.	9. Corundum.
5. Apatite.	10. Diamond.

[2] See page 30.

[3] The luster of the diamond.

[4] The luster of broken glass.

distinction can be readily made. The diaphaneity [1] of sapphire varies from transparent to translucent; of corundum, from translucent to opaque; while emery is opaque. The index of refraction [2] of corundum is 1.76. This high index of refraction accounts for the great brilliancy, when the gems are properly cut and polished.

ARTIFICIAL PRODUCTION OF CORUNDUM.[3]

Synthetical mineralogists discovered some years ago, that the pure forms of corundum could be reproduced artificially. Increase in knowledge in synthetical chemistry, in the past ten years, has enabled workers in this field to effect the most admirable results in the case of corundum, not only in the production of sapphires, but also in the size of the crystals produced. Gaudin, by means of charcoal, decomposed potash-alum and formed corundum. Ebelmen, by exposing four pints of borax and one of alumina to a high heat, produced crystals of corundum. The result of Deville and Caron's works (the subjection of aluminum to the action of boric acid in a carbon vessel) was corundum, in large rhombohedral plates; the addition of chromium fluoride, in varying amounts, gave color, affording blue, red and fine green sapphires. Meunier obtained corundum by the decomposition of aluminum chloride by magnesium and water vapor, at a high temperature in a sealed tube. Fremy and Feil fused alumina and minium in siliceous earthen crucibles, obtaining "a fusible lead aluminate, which was subsequently decomposed by the silica, setting free the alumina in hexagonal crystals of considerable size, under varying conditions, rubies, sapphires etc., being obtained." "Friedel[4] describes the production of crystals of corundum and diaspore by the wet way, by the action of a solution of soda and amorphous alum, at an elevated temperature. At 450° to 500°, both corundum and diaspor were obtained; at 530° to 535°, only corundum; and at 400°, only diaspore." Fremy, in *Synthese du Rubis*, describes the successful reproduction of rubies by the reaction, at a high temperature, in an earthen

[1] Degree of transparency.

[2] Power of refracting light.

[3] Dana's System of Mineralogy, sixth edition, p. 218.

[4] Dana's System of Mineralogy, sixth edition, p. 1081.

vessel, of a mixture of alumina, with more or less potash, upon barium fluoride, bichromate of potassium being used as coloring matter. The result was rubies well crystallized, clear and of brilliant luster.

CHAPTER III.

ALTERATIONS AND ASSOCIATE MINERALS OF CORUNDUM.

GENERAL OBSERVATIONS.

Corundum undergoes many alterations, which give rise to a series of interesting aluminous minerals. Our knowledge of these minerals, in their relation to corundum, is extremely limited, because of the few workers along this line of investigation, and the difficulties, under which they have labored. This is especially true of the United States, where so few places have been opened up to the investigator, that his scope for careful and comparative study has been rigidly limited, and good material, rare. To Dr. J. Lawrence Smith, and to Dr. F. A. Genth, especially, who made quite an elaborate study of corundum alteration products, we are most indebted for our knowledge of these minerals.[1] As far as known, some of these minerals have not been observed in Georgia, while others, although undoubtedly present, have not yet been differentiated from the group. Nevertheless, descriptions of the most important ones will be an aid to those interested only in mineral

[1] In the discussion of these minerals, the work of both men is used freely.

collection, while to those citizens prospecting for corundum, a knowledge of these minerals will be invaluable, as a guide and clue to the presence of that mineral, on account of their intimate relations to it.

OXIDES OF SILICON.

Quartz, Chalcedony, Opal.

QUARTZ.—Quartz crystals occur penetrated by corundum. Sillem [1] has observed quartz pseudomorphous after corundum.

CHALCEDONY.—This is a cryptocrystalline [2] form of quartz. Usually it is white, grayish-white or brown; other colors have special names. In mammillary and botryoidal forms, it is quite common, as an associate of corundum.

HYALITE.—This is a variety of opal, an amorphous [3] form of silica, with a varying amount of water. It has the chemical composition of quartz plus water; but its opal condition renders it less hard, with a lower degree of specific gravity, and without power of crystallization. It has been found at Corundum Hill, Macon county, N. C., as a botryoidal, colorless and white incrustation upon foliated chlorite and upon corundum; also, of a brown color, upon corundum at Dudleyville, Ala.

HYDROUS OXIDES OF ALUMINUM.

Diaspore, Bauxite, Gibbsite.

DIASPORE.—Diaspore is a hydrated aluminum oxide, with the formula, $Al_2O_3.H_2O$ = alumina 85.0, water 15.0. Crystallizing with orthorhombic symmetry, it occurs in prismatic crystals, foliated masses, in thin scales, and sometimes in stalactitic forms. The crystals are usually flattened, sometimes acicular, with commonly rounded faces and vertical striations. It is usually not quite as hard as quartz, nor as heavy as corundum. The cleavage is very perfect, parallel to the flattened, prismatic face. The luster is brilliant, while the color is a very light shade of green, gray, brown or

[1] Sillem. Leonhaide and Brouns, Jahrbuch, p. 885, 1851.
[2] Flint-like.
[3] Incapable of crystallization.

yellow, to colorless. Beautiful specimens have been found at Chester, Mass., and at Unionville, Chester county, Pennsylvania. It has also been observed at Corundum Hill, N. C.; and, at the Laurel Creek corundum mine, in Rabun county, Ga., it occurs in small tabular, transparent, white crystals, as an associate of the corundum. Dr. Genth considers it a result of the hydration of corundum, and asks, if, like corundum in spinel, it may not be so minutely distributed, as to be concealed to the sharpest investigation. Dr. J. Lawrence Smith, in his Scientific Researches, p. 27, says:—"There is reason to believe, that the mineral will be found in almost every corundum locality." Like Dr. Genth, he thinks, from the fact that, when imbedded together, the line of gradation is imperceptible, that diaspore may be so intimately mixed with some corundum, as to escape detection; and hence, by means of it, he would explain the presence of water in many corundums.

BAUXITE.—This mineral is of especial interest in Georgia, because the Coosa valley of Georgia and Alabama is one of the two localities in the United States, which yield bauxite in commercial quantities; the other is the Arkansas locality. The former region was briefly described by Dr. C. Willard Hayes,[1] Assistant United States Geologist, in a paper read before the Virginia Beach meeting of the American Institute of Mining Engineers, February, 1894. Reports upon the same region, also, have been made by Henry McCalley,[2] Assistant Geologist of Alabama, and Dr. J. W. Spencer.[3]

J. W. Hawkins's work near Hermitage, Floyd county, Ga., in 1887, was the first mining of the kind done in America; and, up to October, 1891, 4,000 tons[4] had been taken out of one pit without reaching the bottom of the deposit. This deposit is one of many lying in a narrow belt, which extends from Adairsville, Ga., about sixty miles, to the vicinity of Jacksonville, Ala. Besides the de-

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[1] The Geological Relations of the Southern Appalachian Bauxite Deposits; C. Willard Hayes, Trans. Am. Inst. of Mining Eng.

[2] Alabama Bauxite; by Henry McCalley, Proc. Ala. Indus. and Sci. Soc., 1898.

[3] Geology of the Paleozoic Group of Georgia; J. W. Spencer, 1898.

[4] Geology of the Paleozoic Group of Georgia; by J. W. Spencer, 1898, p. 228.

posit just mentioned, this mineral has been worked on a commercial scale at two points near Rome, Ga.; one, five miles north, the other, six miles south of Rome; it has also been worked near Rock Run, Ala. Dr. Spencer says:[1]—"The quantities of the Georgia bauxite are extensive; and, with the increasing demand, a large supply can be obtained."

Bauxite occurs, either in round grains, disseminated or compact, or as earth and clay-like matter. The color depends upon the extent of iron staining, and is white, grayish, ochre-yellow, brown and red. Bauxite is another form of hydrated alumina; and it so closely resembles diaspore in composition, as to be given the same chemical composition by some authors. Dana, in his formula, however, doubles the amount of water. Ferric oxide is usually present; sometimes, in large amount, replacing the alumina; at others, as an impurity.

To be marketable, bauxite must contain not more than 3.5 per cent. of iron or 20 per cent., or thereabouts, of silica; nor must it contain less than 55 per cent. of alumina. Titanic acid is generally present in the Coosa valley bauxite; but this is not objectionable. Spencer, in his chapter on aluminum, in volume just cited, has given the following analyses of bauxite from the belt in Georgia: —

ANALYSES OF GEORGIA BAUXITE.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Alumina.	46.72	52.13	39.75	56.10	58.61	43.18	36.86	59.82	51.22	53.31	45.21	61.25	67.53	60.61	60.63	68.82
Ferric Oxide.	2.14	1.12	1.62	10.64	2.63	8.74	1.28	2.16	4.83	12.92	0.52	1.82	trace.	0.21	trace.	0.21
Silica	29.01	19.56	41.47	2.56	8.29	28.11	40.02	6.62	13.31	1.16	35.88	1.98	2.92	4.18	4.76	2.13
Water	20.15	24.21	16.14	30.10	27.42	19.22	20.64	31.10	29.82	29.60	17.13	31.43	1.34	2.47	3.20	4.04
Titanic Acid.	0.87	2.08	....	....	3.15	....	....	....	....	3.22	....	2.38	28.00	32.00	31.00	31.50

No single hypothesis has yet been offered to explain acceptably all occurrences of bauxite. The bauxite of Southern France apparently originated by the breaking down of basalt and its subsequent residual deposition. The origin of the Arkansas deposits, which occur in well stratified beds in tertiary rocks, is connected, by

[1] Geology of the Paleozoic Group of Georgia; by J. W. Spencer, 1893, p. 228.

State Geologist Branner, with the contact eruptives; while the Georgia deposits, Dr. Spencer evidently considers, to have been formed by the precipitation of alumina "in the lagoons, in which the ferruginous and manganiferous clay-limestones were being formed." The alumina, he considers, to have been derived from the weathering of the country rocks. Dr. Hayes, on the other hand, who has made an admirable map of the region, and given it much study, finds[1] the deposits of the Coosa valley to be directly upon faulted contacts, and concludes that "such enormous dislocation of the strata generated a large amount of heat. The fractures facilitated the circulation of water; and, for considerable periods, the region was probably the seat of many thermal springs. These heated waters appear to have been the agent, by which the bauxite was brought to the surface in some soluble form, and there precipitated." This accords with the theory of Auge, who has called attention to the formation of hydrated alumina in the Yellowstone region.

The association of bauxite with corundum has been noted in the bauxites of Southern France. Here occasional grains of corundum nave been observed enclosed by bauxite. This called forth the interesting remark from T. Sterry Hunt,[2] that sufficient heat will convert bauxite into corundum, and that these grains of corundum encased in bauxite would seem to show, that even, at ordinary temperatures, the change may take place. Dr. Genth[3] denies this flatly, saying that, on the contrary, this proves quite conclusively to him, that the presence of corundum in the bauxite shows the bauxite to be the alteration product of corundum.

Attempts have even been made, to explain, by common origin, the bauxite and corundum formations of Georgia on the ground, that the corundum belt is a direct continuation of the bauxite belt. In conclusion, I might say, that, whatever may be the relation between corundum and bauxite in Southern France, any attempt to

[1] The Geological Relations of the Southern Appalachian Bauxite Deposit; by C. Willard Hayes—Trans. Amer. Inst. Min. Eng., 1894.

[2] T. Sterry Hunt, Amer. Jour. of Sc., 2nd series, Vol. XXXII, p. 288.

[3] Contri. from Lab. Univ. Pa., No. 1, F. A. Genth, p. 18.

harmonize the two belts in Georgia must show an utter failure, to appreciate their wide differences in geological relations.

Gibbsite.—This is a rare mineral, and has been observed only in two localities, in connection with corundum. Dr. Smith[1] mentions two specimens of hydrargillite (an old name for gibbsite) from Gumuch-dagh, one a hexagonal prism, the other coating a crystal of corundum. The former, Dr. Genth, presumes to have been a pseudomorph after corundum. T. S. Seal[2] found at Unionville, Pa., gibbsite in the form of mammillary crustations, coating albite.

The composition of gibbsite is given as $Al_2O_3.3H_2O$ = alumina, 65.4, water, 34.6. It crystallizes in the monoclinic system, in a tabular form. It also occurs in stalactitic, mammillary and incrusting forms. It is tough, with an eminent cleavage parallel to the basal plane. The color is white, grayish, greenish or reddish-white. When breathed upon, it has a clayish odor.

Dr. Spencer[3] mentions the occurrence of stalactitic, mammillary and incrusting forms, found on the Barnsley estate, Floyd county, Ga., in connection with bauxite. It has not yet been seen in any *corundum locality* in this State.

ANHYDROUS OXIDES OF OTHER METALS.

Spinel, Hematite, Rutile, Ilmenite, Titanite.

Spinel.—Spinel is the name given to a mineral of the Isometric system, whose formula is $MgAl_2O_4$, it being one of the principal species of the spinel group, which bears its name. Of its four varieties, *ruby spinel* is a common associate with the true ruby; *picotite* is common in peridotites and the serpentine derived from them; and *hercynite* has been described by Professor G. H. Williams, as an associate of magnetite and corundum, in the "Cortlandt Series."

The spinel of Corundum Hill, Macon county, N. C., is generally massive, coarsely to finely granular, and black or dark-

[1] Scientific Researches; J. Lawrence Smith, page 26.

[2] T. S. Seal, Amer. Jour. of Sc., 2nd series, Vol. XI, page 267.

[3] Geology of the Paleozoic Group of Georgia; J. W. Spencer, 1893, page 213.

green in color. It has been found to be mixtures of several spinels. From this locality, Colonel Joseph Willcox, of Philadelphia, has a pseudomorph of black spinel after corundum, the crystal being enclosed in a foliated chlorite. At Dudleyville, Tallapoosa county, Ala., black spinel, surrounded by patches of yellowish-white, cleavable corundum, occurs in chlorite.

GAHNITE, a zinc spinel, with the formula, $ZnAl_2O_4$, was observed by Dr. Smith in association with the corundum at Gumuchdagh, Asia Minor.

MAGNETITE, the proto-sesquioxide of iron, $FeO.Fe_2O_3$, forms a part of most emery, and is present in the country rocks.

CHROMITE, $FeCr_2O_4$, the principal ore of chromium, is seldom absent from the chrysolites of corundum formations, where it occurs as a constituent of the rocks, in veins, in bedded masses, and disseminated in minute crystals through the chrysolite. Embedded masses of it occur at Hog Creek, near Hiawassee, Towns county, Ga., where it is encrusted with genthite.

HEMATITE.—Hematite is sometimes associated with corundum, as an intimate mixture, forming in part the variety of corundum known as emery.

RUTILE.—This is a rare associate of corundum.

ILMENITE.—This mineral is found associated with corundum in New York State; also at Chester, Mass. With it are generally present rutile, spinel etc.

TITANITE.—This mineral is, in rare instances, an alteration product of rutile and ilmenite; hence it is sometimes present with corundum.

ANHYDROUS SILICATES.

Enstatite, *Anthophyllite*, *Amphibole* (Tremolite, Actinolite, Asbestus, Smaragdite), *Chrysolite*, *the Feldspars*, *Zoisite*, *Fibrolite*, *Kyanite*, *Tourmaline*, *Staurolite*.

ENSTATITE.—Good specimens of enstatite have been found at the various corundum mines in North Carolina, associated with corundum. Enstatite is an orthorhombic member of the pyroxene group, having the formula, $MgO.SiO_2$ = Silica 60, magnesium 40 = 100 ;

sometimes a little iron is present with the magnesium. In color, it is grayish-white, yellowish-white, greenish-white to olive-green and brown, according to its percentage of iron. Distinct crystals are rare, and of prismatic habit. It usually occurs massive, fibrous or lamellar.

ANTHOPHYLLITE.—This mineral crystallizes in the orthorhombic system, and is an orthorhombic member of the amphibole group. It is a magnesium ferrous silicate $(Mg,Fe)SiO_3$, and corresponds to enstatite, bronzite and hypersthene of the pyroxene group. Crystals are rare, and of prismatic habit. In association with corundum, it is commonly lamellar or fibrous massive, often occurring in forms resembling asbestus. It forms part of most corundum-bearing formations, as massive rock, in which anthophyllite is frequently radially arranged with actinolite. The color of anthophyllite is usually of a brownish shade, sometimes of a clove-brown, from which its name is derived.

TREMOLITE.—Tremolite is a calcium-magnesium variety of the species, amphibole ; its formula is $Ca\ Mg_3\ Si_4O_{12}$ = silica 57.7, magnesia 28.9, lime 13.4 = 100. Ferrous iron replacing magnesium is frequently sparingly present, only up to 3 per cent. It crystallizes in the monoclinic system in distinct crystals, which are often in thin, flat blades. It is white to dark-gray in color, and sometimes transparent and colorless. Tremolite has been distinguished at various corundum mines in North Carolina, and at the Laurel Creek corundum mine in Rabun county, Ga.

ACTINOLITE.—Actinolite, another variety of the amphibole species, has been distinguished at all the Georgia corundum properties. It occurs also in the Pennsylvania and North Carolina corundum localities. It is a calcium-magnesium-iron amphibole, with the formula, $Ca(Mg,Fe)_3\ Si_4O_{12}$. Its color, due to ferrous iron, is bright-green and grayish-green. It crystailizes in the monoclinic system. The crystals are common, either short or long bladed, as in tremolite ; it also occurs columnar, fibrous and granular-massive. Beautiful specimens of bright-green columnar crystals, several inches in length, and often fully one third of an inch in width (longest horizontal axis), are found in talc, south of Ac-

worth, Paulding county, and near Monroe, Walton county, Ga. Talc is the most frequent matrix of this mineral.

ASBESTUS.—Tremolite, actinolite and other varieties of amphibole (except those containing much alumina), when so fibrous that the fibers are threadlike, are called asbestus. Chrysotile, the fibrous variety of serpentine, is often confused with, and is much used as, asbestus. It is distinguished from asbestus, however, by the presence of water. Being fire-proof, and the finer grades being so easily woven into cloth, asbestus has been used for centuries. Pliny speaks of it as a "vegetable growth," and says that it is good for making incombustible cloth. The ancients had high regard for asbestus, because the cloth made from it could be easily made undefiled by throwing it into fire, and thus purifying it.

Asbestus is present in many of the corundum properties in this State; but, as far as observed, it is of an inferior quality. The fibers, though long, are without strength, and when a mass is exposed to the air, it becomes very hard on account of the presence of hydrous-iron sesquioxide, which has seeped into it. Various properties have been prospected for asbestus, and considerable of the material has been shipped; but industries of this nature have never continued longer than a few months. In Nacoochee Valley, White county, a large plant has just been established, and "asbestus rock," as they call it, is being "defiberized" for the market.

SMARAGDITE.—A rock, formed of a grass-green hornblende, feldspar and grains of pink to deep ruby corundum, has attracted considerable attention, because of its beauty and its occurrence in only a few corundum localities of North Carolina and Georgia. This grass-green mineral was, and is now, commonly called *smaragdite*. Charles Upham Shepard, Sr.,[1] speaks of it as *arfvedsonite*, to which it bears no resemblance. Dr. Genth, from an analysis, by Chatard, of a representative specimen from Cullakenee Mine, North Carolina, calls it *kokscharoffite*, after an aluminous amphibole. According to the last edition of Dana's System of Mineralogy,[2] sma-

[1] Corundum Region of North Carolina and Georgia, by C. U. Shepard, Sr., Amer. Jour. Sci., 3rd series, Vol. IV., Aug. and Sept., 1872.

[2] The System of Mineralogy of James Dwight Dana, sixth edition, by Edward S. Dana, 1892.

ragdite is "a thin, foliated variety of amphibole, near actinolite in composition, but carrying some alumina. It has a light grass-green color, resembling much common green diallage." As a variety, based on color, this mineral has as much claim on mineralogists as hiddenite and other similar varieties.

CHRYSOLITE.—This mineral usually occurs in embedded grains with chromite, forming the so-called "chrysolite formations," in which the corundum of this region occurs. It crystallizes in the orthorhombic system, with crystals often flattened, and sometimes elongated. The cleavage is rather distinct in one direction, but less so in another, while the fracture is conchoidal. The color, as found in this region, is usually olive-green. The chemical formula is $2(Mg, Fe)O.SiO_2$, in which the magnesium and iron vary widely. Titanium dioxide, tin and nickel are sometimes present in small quantities. It is infusible in most cases; but it is decomposed by hydrochloric and sulphuric acids, with the separation of gelatinous silica.

THE FELDSPARS.—The feldspars, which are present in corundum localities, belong to the plagioclase species, or lime-soda feldspars, that is, albite and anorthite, and their isomorphous mixtures. The chemical composition of the theoretical albite is $Na_2O_3.Al_2O.6SiO_2$; that of anorthite is $CaO.Al_2O_3.2SiO_2$. All the other lime-soda feldspars are isomorphous mixtures of albite and anorthite $= Ab_n An_m$. A few, which occur most frequently, have received particular names. Tschermak has brought these together into a table, which may be enlarged by the addition of any of their compounds. The average specific gravity of Tschermak and Goldschmidt is attached, and also their hardness:—

Species.	Composition.	Sp. Gr.	Hardness.
Albite	Ab_1,An_0 to Ab_8,An	2.62	6 - 6.5
Oligoclase	Ab_6,An_1 to Ab_2,An_1	2.64	6 - 7
Andesite	Ab_3,An_2 to Ab_4,An_3	2.65	5 - 6
Labradorite	Ab_1,An_1 to Ab_1,An_2	2.69	5 - 6
Bytownite	Ab_1,An_3 to Ab_1,An_6	2.71	....
Anorthite	Ab_1,An_8 to Ab_0,An_1	2.75	6 - 6.5

It will be observed, that the specific gravity increases with the percentage of anorthite. By means of the specific gravity, owing to the great exactness, with which the density of a heavy solution can be regulated, this determination of the feldspars is very reliable, so long as the material is pure and fresh. The presence of foreign matter, or any alteration, will lessen this certainty; for instance, a kaolinization would lessen, while the development of carbonates, the formation of mica etc., must increase the specific gravity.

Members of this group are characterized by their brittleness, easy cleavage and glistening cleavage-face. Their structure is either compact cleavable, lamellar or granular. Their color is white, gray or reddish. All crystallize in the triclinic system.

Bournon, in 1802, described, as *indianite*, certain white, gray and reddish granular feldspars, which form a matrix for corundum, in the Carnatic. This was subsequently discovered to be anorthite. The associate feldspar with corundum at Chester, Mass., at Unionville, Pa., and at certain mines in North Carolina seems to be *oligoclase*. In Dr. Smith's paper, analyses of several feldspars, which have altered from corundum, show them to be oligoclase.

ZOISITE.—This mineral has the following chemical formula:— $4CaO.3Al_2O_3.6SiO_2.H_2O$ = silica 39.7, alumina 33.7, lime 24.6, water 2.0=100. The alumina is sometimes replaced by iron, thus graduating toward epidote, which has the same general formula, but from which it was separated some years ago on crystallographic ground. The crystals are orthorhombic in symmetry, with prismatic type, deeply striated or furrowed vertically, and seldom distinctly terminated. Also massive, columnar to compact. It also occurs commonly in crystalline masses longitudinally furrowed.

Zoisite is brittle, with uneven fracture. The cleavage is very perfect parallel to the brachydome. Hardness, 6 to 6.5. On the cleavage face, the luster is pearly; otherwise it is vitreous. The color ranges from grayish-white, gray, yellowish-brown, greenish-gray to apple-green. A peach-blossom red and rose-red variety, is called *thulite*.

As an associate of corundum in the United States, it was de-

scribed under the name of *unionite* by Silliman, who found it at Unionville, Pa., in company with euphyllite. Fine specimens have been found at the Cullakenee Mine, N. C. Genth says of the latter, that many of the specimens show distinctly, that it is the result of the alteration of corundum. The pink corundum is often surrounded by a thin coating of white zoisite. Other specimens show corundum altering on the outside to zoisite, and on the interior to margarite.

In the corundum regions of Georgia, zoisite has been found only at Hog Creek mine, near Hiawassee, Towns county.

Fibrolite.—This is a fibrous, firm and compact variety of sillimanite. It is sometimes radiated, and is grayish-white to pale brown and pale olive-green in color. It has been known for a long time, to accompany corundum in the Carnatic, in India, and near Canton, China. Interesting specimens of corundum, showing alteration into fibrolite, have been noticed from the Falls of the Yantic, near Norwich, Conn., from Burke county, N. C., from Laurens county, S. C., from Mineral Hill, Delaware county, Pa., and, lately, from several other places in North Carolina. When the alteration has just begun, the fibrolite appears as a very thin, vitreous incrustation. Specimens have been found in all stages, even to the complete disappearance of the corundum; in the latter instance, a fibrolite pseudomorph after corundum remains.

Kyanite.—The empirical formula of kyanite is uncertain. It is regarded by some as a basic orthosilicate, $Al_2O_3.SiO_2$, like andalusite and sillimanite, while by Groth it is considered a metasilicate, $(AlO)_2 SiO_3$. It crystallizes in the triclinic system, and is usually found in long bladed crystals rarely terminated. The macropinacoids or flat blade faces are often striated horizontally. It also occurs coarsely bladed, columnar to subfibrous. Cleavage on the macropinacoids, very perfect. The hardness varies from 4 to 7.25 according to direction. Color, blue to white ; blue along center of blade with white margin. It also occurs gray, green and black.

It is often associated with corundum at Litchfield, Newton and Washington, Conn. It occurs in large roll masses with corundum and massive apatite. In North Carolina, it is found at several cor-

undum mines, associated with corundum and muscovite, which, according to Genth, is derived from the alteration of the corundum. In Georgia, as an associate of corundum, it is found near Powder Springs, Cobb county.

TOURMALINE.—Dr. Smith found tourmaline in great abundance with the emery of Naxos, and in less quantities in other localities, disseminated through the emery. In the United States, most interesting specimens have been collected.

Colonel C. W. Jencks found a pseudomorph of tourmaline after corundum at Corundum Hill, N. C. The length and breadth of the crystal is about two inches. It shows the planes of the hexagonal prisms and portions of one pyramidal plane. Almost the entire crystal has altered into black tourmaline, leaving only a shell one-fourth of an inch thick, while the lower part is mixed with corundum. Plates of green chlorite penetrate the crystal. From Unionville, Pa., Dr. Isaac Lea mentions a crystal of transparent green tourmaline passing through the middle of a prism of diaspore, the whole enveloped by lamellar crystals of pearly muscovite. The associate tourmaline of corundum is commonly black. The triangular prism predominating, it is readily distinguished from common black hornblende, which it resembles somewhat closely, by examining a cross-section of the crystal, which is either three, six or nine sided. It has a strong tendency toward crystallization; hence crystals, usually prismatic in habit and often slender to acicular, are very common. The prismatic faces are very strongly striated, vertically, often giving a rounded appearance to the crystals. The crystals frequently occur alone, but often in parallel and radiating groups. A columnar and black variety is often confused with common hornblende; but its lack of cleavage and its coal-like appearance on a broken surface aid in distinguishing it. Tourmaline is almost wanting in cleavage, and is brittle even to friable. The hardness is 7.5. Its chemical formula is uncertain. Tourmaline is a complex silicate of boron and aluminum, with either magnesium, iron or the alkali metals prominent. Tourmaline has been found in Georgia, at the Laurel Creek corundum mine, Rabun county, and at the Hog Creek corundum mine, near Hiawassee, Towns county.

STAUROLITE.—This mineral usually occurs in cruciform twins; and, on this account it has been much worn as an amulet. Just at this time, it is quite the fashion to carry small twin crystals of staurolite in the pocket, and call them "good luck stones." The crystals are orthorhombic; they have distinct, but interrupted, cleavage, parallel to the brachypinacoid; they are brittle, and have a subconchoidal fracture. In color, staurolite is dark reddish-brown to brownish-black; and in diaphaneity, it varies from translucent to nearly opaque. Its hardness is 7 to 7.5; and its specific gravity, from 3.65 to 3.75. The chemical formula is $HAl_5FeSi_2O_{13}$, in which the Aluminum is partly replaced by ferric iron, and the ferrous iron by magnesium and manganese. Genth analyzed a few minute massive brown grains of a mineral associated with damourite, and resulting from the alteration of corundum, at the Corundum Hill mine, Macon county, N. C., and found them to be staurolite. The specific gravity was 3.711.

HYDROUS SILICATES.

Micaceous Minerals.

The micaceous minerals, associated with corundum, will be considered in the following order, viz:—

1. Micas.
2. Clintonites.
3. Chlorites.
4. Vermiculites.

The *micas* include the micas proper, that is, those micaceous minerals, characterized by a highly perfect basal cleavage, yielding very thin, tough and more or less elastic laminæ. *Clintonites*, or the brittle micas, form a transition between micas and chlorites. They include those micaceous minerals, which are near the micas in cleavage, crystalline form and optical properties, but which differ from them physically, in the brittleness of the laminæ, and chemically, in their basic character. The *chlorites* include a large number of ferrous magnesium-aluminum silicates of micaceous character, but whose laminæ are tough and comparatively inelastic. They are usually green in color, and hence are called chlorites. The *vermiculites* form a supplementary group, being chiefly hydrated com-

pounds, resulting from the alteration of the micas. They are, in part, closely related to the chlorites; but they vary from the chlorites somewhat widely in composition.

All these species are characterized by their highly perfect basal cleavage; and they yield easily thin laminæ. They all crystallize in the monoclinic system, and imitate so closely hexagonal or rhombohedral symmetry, that it is only within the last few years, that their true symmetry has been recognized. They are more or less closely related in the angles of prominent faces. They are classed as hydrous silicates, but not strictly, since the water they yield upon ignition may be regarded, probably in all cases, as water of constitution.

MICAS.

Phlogopite, Muscovite (Damourite, Ephesite, Lesleyite), *Paragonite* (Euphyllite.)

PHLOGOPITE.—A magnesian mica, especially characteristic of serpentinous formations. The crystals are often large and coarse, usually only six-sided prisms, more or less tapering, with irregular sides. Cleavage, highly eminent; laminæ, tough and elastic. Hardness, 2.5 to 3; specific gravity, 2.78 to 2.85. Its color is yellowish-brown to brownish-red; also pale brownish-yellow, green, white and colorless. It is commonly present in chrysolite formations. Beautiful small crystals have been found in the Laurel Creek corundum mines, Rabun county; and, in 1889, large quantities of a heavy, foliated kind, intimately associated with a massive asparagus-green apatite, were taken from one of these mines. Analysis, in the laboratory of the U. S. Geological Survey, showed that this phlogopite had begun alteration to a vermiculite.

MUSCOVITE (Damourite).—Damourite, for a long time supposed to be a distinct species, was proved by Dr. Genth, six or eight years ago, to be muscovite. Under damourite, as a variety, are included, in the last edition of Dana's System of Mineralogy, margarodite, gilbertite, hydro-muscovite and most hydro-mica in general. The foliæ are less elastic than muscovite; the luster is somewhat pearly or silky; and they feel unctious like talc. The scales

are usually small; but it passes into forms, which are fine scaly or fibrous, as sericite, and finally into a compact crypto-crystalline form. It is often derived by alteration from kyanite, topaz and corundum.

Damourite is one of the most important alteration products of corundum. It may be formed, by direct alteration of corundum, or from some of its changed conditions. Besides this, it varies so in appearance, that surety of correct diagnosis necessitates a chemical analysis. The manifold nature of damourite is shown in the dissemination of the mineral as pseudomorphs after silicates. Dr. Genth notices pseudomorphs after corundum from Unionville, Chester county, Pa., from North Carolina, and from Laurens county, S. C.

Ephesite and Lesleyite.—Dr. J. Lawrence Smith[1] first noticed the former of these from Gumuch-dagh, and gave it the name *ephesite*, because of its occurrence near the ancient city of Ephesus. This is a mechanica lmixture of corundum and damourite, or the result of an almost complete alteration of corundum into fibrolite and the subsequent alteration of the latter into damourite. Dr. Isaac Lea called a similar mixture from Unionville, Pa., lesleyite, not observing, that the material was a mixture of two minerals. This mineral substance, according to Dr. Smith, resembles white kyanite of lamellar structure. Dr. Genth describes lesleyite as fibrous and compact, fibrous-columnar, fibrous and divergent, with a grayish-white color to reddish, depending on the presence of iron. The hardness is given at from 4 to 7.

PARAGONITE.—This is a soda mica, corresponding to muscovite in composition. It commonly forms a mass of rock, containing kyanite, staurolite, garnet and tourmaline, called *paragonite schist*. Its association, in Saxony and elsewhere, with corundum, leads Genth to ask, if these paragonite schists may not be the result of the alteration of corundum passing through the stage of fibrolite and damourite.

EUPHYLLITE.—This is a sodium-potassium mica, apparently intermediate between muscovite and paragonite, but more basic. It is a rare associate of corundum at Unionville, Pa.

[1] Amer. Jour. Sci. (II) 59, 1851. 48, p. 254, 1869.

CLINTONITES.

Margarite, Chloritoid.

MARGARITE.—Its name is derived from the Greek word for pearl. It is characterized by a pearly luster on a cleavage face. Its hardness is 3.5 to 4.5, and its specific gravity varies from 2.99 to 3.08. In color, it is grayish-white, pink or yellowish. It is commonly associated with corundum, and in many cases is obviously formed directly from it. Smith and Silliman discovered it, almost simultaneously, in Asia Minor and Greece, and in Pennsylvania and South Carolina respectively. Since then, it has been discovered in many corundum localities; but, on account of certain forms of damourite, which resemble it closely, an analysis is necessary to prevent confusion. An analysis of this mineral from Gainesville will be found on page 99.

CHLORITOID.—Chloritoid has been found in many corundum localities. It was noticed by Smith to be in abundance with the emery of Gumuch-dagh, covering the surface of emery blocks, and sometimes entering largely into the substance of the emery. From this, it was very apparent to him, that it was formed by elimination from the mass of emery at the time of its consolidation.

The crystals are grouped in rosettes. When massive, which is its usual habit, the foliæ are coarse and often bent or curved, and brittle. Its hardness is 6.5, and its specific gravity, 3.52 to 3.57. In color it is dark-gray, greenish-gray, greenish-black and grayish-black.

CHLORITES.

Prochlorite, Corundophilite.

Strict lines of division between the chlorites is extremely difficult, and a correct interpretation of their composition is equally so, neither having, as yet, been satisfactorily accomplished. Chemically considered, the chlorites are silicates of aluminum, ferrous iron and magnesium, chemically combined with water. Chromium may be present in small amount, replacing a part of the aluminum, in which case, the color is pink instead of the common green. Ferric iron is also sometimes present, replacing a part of the alu-

minum. Calcium and the alkalies, characteristic of all true micas, may be present in small amounts; but they are usually conspicuous by their absence. The chlorites, which are about to be described, belong to a distinct series, showing a constant percentage of water, and a decrease of silica, magnesia and ferrous iron, accompanied by an increase in aluminum. Since, however, it is impossible to distinguish them, except by chemical analysis, the varieties, which have been found associated with corundum, will be considered together.

PROCHLORITE, CORUNDOPHILITE.—Externally, these two chlorites are indistinguishable. Both are monoclinic, and occur, either as six-sided tables or low prisms, or massive, foliated or granular. Both possess the same color, viz., green, grass-green, olive-green, blackish-green. In the case of prochlorite, the laminæ are simply flexible, while corundophilite laminæ are somewhat elastic.

Varieties of these, not too near the division line, will present certain optical differences. Chemical analysis, therefore, is absolutely necessary for a safe determination of these species. As has been said previously, an increase in alumina will show a decrease in silica, magnesia and ferrous iron. Corundophilite, therefore, can be distinguished from prochlorite, by its possessing more alumina and less silica, ferrous iron and magnesia. Prochlorite usually has a large amount of ferrous iron; but analyses of the prochlorite found associated with corundum at Corundum Hill, North Carolina, show only a small percentage.

THE VERMICULITES.

Jefferisite, Culsageeite, Kerrite, Lucasite, Painterite, Maconite, Dudleyite, Willcoxite.

The vermiculite group represents a large number of micaceous minerals, which, in the main, are alteration products of the micas. They are closely related to the chlorites; but they vary from them somewhat widely in composition. Many of them have a more or less indefinite chemical nature, varying with the degree of alteration of the original minerals. The laminæ may be said, in general, to be soft, pliable and inelastic; the luster is pearly or bronze-like,

according to color, which varies from white, through shades of yellow, to brown. Dried over sulphuric acid, or heated at from 100° to 110° C., they lose, up to ten per cent. of water; at 300°, more water is given off, and, at red heat, a somewhat large proportion is given off. This drying process leads to the common physical character of exfoliation, which is common to nearly, if not all, the vermiculites, causing them to expand, when heated, into worm-like threads. This physical change caused the name vermiculite to be given to the oldest member of the group, from the Latin, *vermiculari*, to breed worms.

Vermiculites are extremely common in corundum veins, in some instances forming the complete gangue for the mineral. This is instanced at the Corundum Hill mine, North Carolina, where Chatard[1] speaks of a so-called "sand-vein," made up of a vein-like mass of brown vermiculites, containing an abundance of small corundum crystals. Again, in his sections:—In section A, he finds a six-inch seam of vermiculites; in Section B, twelve inches of fine, scaly, brown vermiculite; and in section C, a six-inch streak of vermiculite. Vermiculites also play a prominent part in the corundum veins of the Laurel Creek mine, and certain other corundum localities of Georgia.

JEFFERISITE (Culsageeite.)—The culsageeite variety of jefferisite comes from Corundum Hill mine, near Cullasagee Post-office, N. C. It consists of broad crystalline plates, of eminent cleavage and pearly luster. The color is yellowish-brown to brownish-yellow. It shows very well the characteristic of exfoliation on heating. Here, it is formed from the alteration of a chlorite, which very frequently shows an incipient alteration to this mineral, by a discoloration to brown or brownish-yellow.

KERRITE.—Kerrite was named by Dr. Genth, in honor of the late Professor W. C. Kerr, State Geologist of North Carolina. It consists of innumerable fine scales, which, under the microscope, present no definite shape. Its color is pale greenish-yellow with a tint of brown, and its luster is pearly. It does not exfoliate as readily as jefferisite.

[1] Bul. 42, U. S. Geol. Survey, T. M. Chatard.

LUCASITE.—This mineral was found to be a new vermiculite species, by Dr. T. M. Chatard, who discovered and analyzed it. He named it for Dr. H. S. Lucas, who has been such an indefatigable worker, in developing the corundum deposits of Georgia and North Carolina. This vermiculite occurs with actinolite at Corundum Hill, N. C. The foliæ are small, compact and disseminated; and they exfoliate largely on ignition. It is easily decomposed by hydrochloric acid.

PAINTERITE.—This vermiculite occurs at the Corundum mine in Newlin township, Chester county, Penn., as a dull green mineral; and, as a golden-yellow mineral, it is found on the farm of James Painter, Middletown, Delaware county, Penn., for whom it was named. In the former color, it much resembles culsageeite, both outwardly and optically.

MACONITE.—This species discovered by Genth, closely resembles fine scaly jefferisite. The scales are harder than kerrite, and are irregular. It exfoliates largely upon heating, and fuses with difficulty to a brown glass. It is easily decomposed by hydrochloric acid, with a separation of silica in scales.

DUDLEYITE.—This vermiculite is an alteration product of margarite. It is found in large quantities at Dudleyville, Ala. Genth describes it, as a soft bronze or brownish-yellow mineral, which still retains the form and pearly luster of margarite. When heated, it exfoliates very slightly, and melts with difficulty into a brownish-yellow blebby mass. It decomposes easily in hydrochloric acid, with the separation of silica in pearly scales. This mineral is also found in the North Carolina corundum regions.

WILLCOXITE.—This was named by Genth for Colonel Joseph Willcox of Philadelphia, Penn., the well known amateur collector of American minerals and fossils. It occurs as a coating around a nucleus of corundum, and is presumed to be an alteration of it. It occurs at Shooting Creek and Cullakenee Mines, Clay county, N. C. The scales are white to greenish or grayish-white, with pearly lustre, resembling talc. Before the blow-pipe, in thin splinters, it fuses with difficulty into a white enamel, coloring the outer flame yellow. It decomposes with difficulty in hydrochloric acid, with the separation of silica in pearly scales.

THE SERPENTINE AND TALC GROUP.

Serpentine, Genthite, Talc.

This group, containing serpentine and talc, as the leading members, is closely related to the chlorite group. Included with them are some amorphous, magnesian silicates, such as genthite.

SERPENTINE.—Serpentine crystallizes in the monoclinic system. Its composition is that of a hydrous magnesian silicate. Crystals of serpentine are sometimes found in the chrysolite rocks, but only as pseudomorphs after chrysolite. It is usually massive, and occurs in these chrysolite rocks as an alteration product. It also occurs delicately fibrous and silky, in which form it is extensively used for asbestus. The color is from yellowish-green to blackish-green, and sometimes red and black. Massive serpentine, more or less pure, frequently occurs as an alteration of chrysolite or pyroxene; but it has not been observed in connection with the corundum-bearing magnesian formation of Georgia. The chrysolite rocks of these formations are frequently spoken of as serpentine, because of their partial serpentinization; but this is a misnomer.

GENTHITE.—This amorphous mineral occurs as an apple-green or a yellowish incrustation on chromite near the Hog Creek mine, Hiawassee, Towns County. It is a hydrous nickel-magnesium silicate, with the formula $2NiO.2MgO.3SiO_2.6H_2O$ = silica 34.8, nickel protoxide 28.8, magnesia 15.3, water 20.9=100. In a closed tube, submitted to heat, it blackens and gives off water; it is infusible before the blow-pipe. When exposed to the air for some time, it loses its apple-green color and breaks down into a powder.

TALC.—Talc is either orthorhombic or monoclinic; it usually occurs in foliated masses, or granular massive; it is also fibrous or compact. When foliated, the foliæ are easily separated; it is soft, and has a greasy feel. The foliated variety is known as *talc*. The fine granular and compact varieties are known as *soapstone* or *steatite;* the very coarse, as pot-stone, because used by the Indians and aborigines of this country for making pots. The fibrous

varieties are usually pseudomorphs after pyroxene. All these varieties occur in chrysolite formations, and are readily distinguished by their softness and greasy feel.

PHOSPHATES.

Apatite, Lazulite.

APATITE.—Apatite is a calcium phosphate, in which either fluorine or chlorine, or both together, are combined with part of the calcium. It crystallizes in the hexagonal system, and has pyramidal hemihedrism. Crystals vary from long to short prisms; they also occur as low pyramids, slightly modified by prismatic faces. The hardness of apatite is from 4.5 to 5, and its specific gravity is from 3.17 to 3.23. Its cleavage is imperfect, and its fracture uneven. It is brittle. Its luster is vitreous, inclining to sub-resinous, and in color it is usually sea-green to bluish-green, though it sometimes occurs white (opaque and transparent), pink, purple, brown and black.

Two pieces of apatite crystals, one four inches, the other two inches in diameter, were given to the Survey, as specimens from the Laurel Creek mine. They are sea-green in color and transparent to translucent. Scales of phlogopite are inclosed by the large piece, and it encases parts of both specimens. This is a rare associate of corundum, and is not mentioned among the minerals of the North Carolina corundum mines.

LAZULITE.—This is essentially an aluminum phosphate, in which are present, in varying proportions, magnesia and iron protoxide, with water. It crystallizes in the monoclinic system; the crystals are usually acute, and sometimes flattened. It also occurs massive, granular to compact. Its cleavage is indistinct, and its fracture uneven. Its hardness is from 5 to 6, and its specifie gravity is 3.05. In color, it is azure-blue. It occurs in abundance with corundum at Crowder's Mountain, Gaston county, N. C. It is not known in Georgia in this association; but beautiful sky-blue crystals, over an inch broad and as long, are found at Graves' Mountain in Lincoln county.

CHAPTER IV.

GEOLOGY OF THE CRYSTALLINE BELT.

INTRODUCTION.
MAP OF GEORGIA.
TOPOGRAPHY OF THE CRYSTALLINE BELT.
STRUCTURE AND PHYSIOGRAPHY OF THE CRYSTALLINE BELT, AND ITS EVOLUTION.
AGE OF THE CRYSTALLINE BELT.
GEOLOGY OF THE HOLO-CRYSTALLINE AREA.

INTRODUCTION.

Introductory to the descriptive chapter on the corundum deposits of Georgia, a brief chapter on the geology of the entire so-called crystalline area will not be amiss. The mineral resources of any region are so dependent upon its geology, that an intelligent view of any one of them requires a general knowledge of the age, structure, lithology and topography of the region, in which it is found. Such are their reciprocal relations, that knowledge of one adds to our knowledge of the other. Likewise the liability of error in conclusion, in regard to any one subject, decreases in proportion to the increase of acquaintance with all.

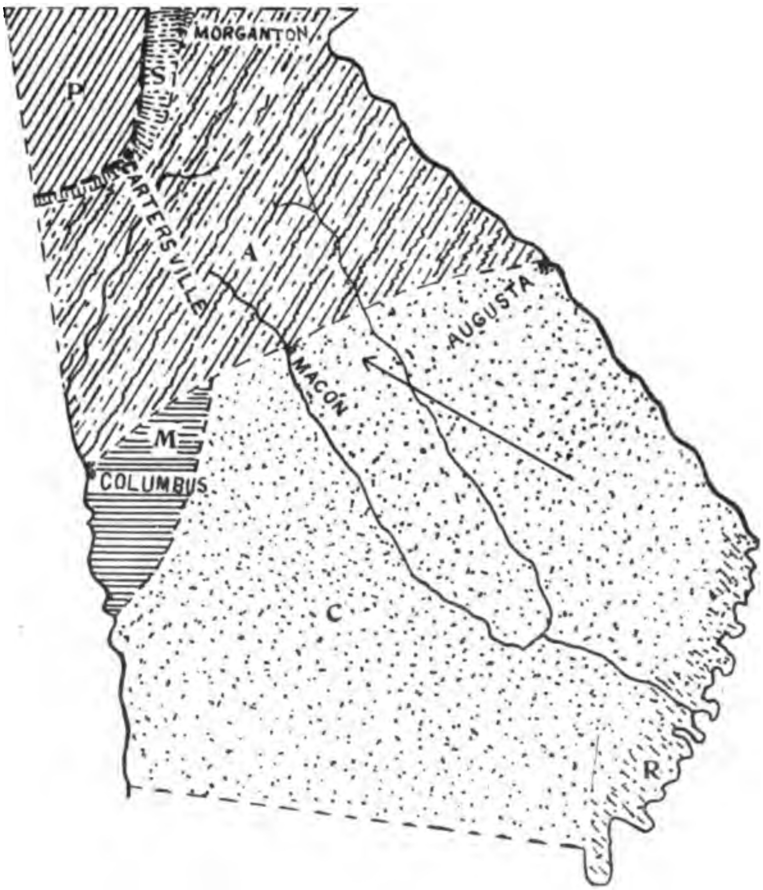
Notwithstanding the importance of detailed geological information, the crystalline belt has received only the most cursory examination. Mapping in detail has been held in abeyance for general prospecting. Attention has been confined to the discovery of economic minerals, to the almost complete exclusion of those things which would have lent acumen to the search. Hence, many facts are wanting for a perfectly satisfactory discussion of the geology of this area. Still, a few general statements in regard to the same may be found useful.

MAP OF GEORGIA.

The last geological map of the entire State was compiled by the Agricultural Department in 1885, and may be seen in the report of that year. Their data was altogether insufficient for a good map; yet, in a rough way, it shows the prominent formations and their distribution over the State.

Spencer, in his "First Report of Progress, 1890–91," maps in detail the area south of a line drawn from Columbus to Knoxville, and west of Flint river. His last report, "Geology of the Paleozoic Group of Georgia and Resources, 1893," contains a detail map of ten of the northwest counties, or the entire northwest corner of the State.

FIG. 4.



GEOLOGICAL OUTLINE MAP OF GEORGIA.

A, Algonkian; S, Semi-crystalline; P, Paleozoic; M, Mesozoic; C, Cenozoic; R, Recent.

From these maps, it may be learned that more than one-half of the surface area of Georgia is covered by the later formations. This area lies south of a line drawn south of west from Augusta, Richmond county, to Columbus, Muscogee county, and is made up of Mesozoic, Cenozoic and recent formations.

The known Paleozoic area of Georgia covers about 3,408 square miles. In it are represented all the systems of the Paleozoic, viz.:—Cambrian, Silurian, Devonian and Carboniferous. The Devonian, Spencer does not map, because the formation is extremely limited, and occurs in valleys; consequently outcroppings are rarely seen. A line drawn south from a point a few miles east of Cohutta Springs, Murray county, to Cartersville, Bartow county, and then south of west to Esom Hill, Polk county, inclosing the northwest corner of the State, sharply defines the limits of the Paleozoic in Georgia. This is known as the "Cartersville Fault."

Between these two areas of the State, and occupying the greater part of North Georgia, is the so-called "Crystalline Belt," with a surface area of about 12,430 square miles. It will be seen, by referring to Fig. 4, that this region is divided into a "semi-crystalline" and a "holo-crystalline" area. Explanation of this division will be found in a following section of this chapter.[1] The line is simply provisional, and makes no attempt at accuracy, leaving that to future mapping. The north and south line, however, separates the two areas fairly well. Less is known of the east and west line.

TOPOGRAPHY OF THE CRYSTALLINE BELT.

The surface of the earth presents a figuration and transfiguration due to natural processes, and "now stands in a transient stage between its past and its future." All these changes have been brought about by two forces, the one *constructive*, the other *destructive*.

The topography of the Crystalline Belt represents the action of these two forces. Great crust movements raised the Appalachian system, of which this belt is a part; these were *constructive*. During these periods of uplifting, atmospheric and aqueous agencies

[1] Structure and Physiography of the Crystalline Belt and its Evolution.

were acting, and have continued to act. These *destructive* forces have sculptured the belt into its present features.

The Crystalline Belt, on account of its crystalline rocks and complex structure, presents a more or less diversified topography. The southern portion of the belt is broken by low, undulating hills, intensified along the large rivers. These elevations increase, as we go north. Then come the foot-hills of the Blue Ridge, culminating in the Blue Ridge itself, peaks of which, in Georgia, range from 3,000 to 4,000 feet above the sea-level, the maximum height being 4,790 feet. This is the highest point in Georgia—Mount Enotah on the southwestern side of Towns county.

The drainage is that, common to all mountainous districts and areas approaching sea-level, or "base level," as it is technically called. The streams present all stages of activity from youth to old age. Tributaries of the Tennessee river drain the belt on the north; the south is drained by the Savannah, Ogeechee, Oconee, Ocmulgee, Flint and Chattahoochee rivers.

Before leaving this subject, an individual topographical feature, showing the wonderful erosive power of a river, is worthy of mention—the Tallulah Gorge in the southern part of Rabun county. Its superb grandeur, people have traveled far to see; as a geological feature, its fame is world-wide. This narrow gorge is several miles long, and nearly a thousand feet deep.

STRUCTURE AND PHYSIOGRAPHY OF THE CRYSTALLINE BELT, AND ITS EVOLUTION.

In the consideration of the structure of the Crystalline Belt, with a view of interpreting the same, it will be necessary to review briefly the structure of Northwest Georgia. North and west of the Crystalline Belt, and occupying the entire northwest corner of Georgia, all the systems of the Paleozoic are represented. Erosion, which has been actively at work, since the uplifting of the Appalachian system, following the Coal epoch, has removed thousands of feet of the various formations, and sculptured the area into its present landscape. The general structure of the region, however, is mainly consequent upon the faults, overthrows and folding pro-

duced by orographic movements. The Paleozoic ceases abruptly, on contact with the Crystalline Belt. A gigantic physical break or unconformity, which C.W. Hayes has aptly termed "The Cartersville Fault,"[1] marks a distinct separation of two regions. The structure of the Paleozoic area has been studied in a most careful manner by Hayes, Campbell and Spencer, and full particulars may be found in Spencer's report on this region, and in the reports and atlas sheets of the U. S. Geological Survey, by Dr. C. W. Hayes. The structure of the Crystalline Belt has only been studied superficially, and sufficient scientific examination has not been made to warrant more than hypothetical conclusions. In working out the detail geology of the Paleozoic, the geologists were in a field much less disturbed by dynamic forces, and therefore still containing abundant paleontological evidence. In the Crystalline Belt, no positive[2] fossil remains have been found, and the rocks are much more disturbed and altered. The rocks of the Crystalline Belt are divisible into two petrographical classes. The first class consists of a series of slate, shale, schist, conglomerate and marble, which, through metamorphism, have become more or less crystalline. These undoubtedly are all clastics, and despite their metamorphosed condition, preserve, in a measure, evidences of their origin; therefore they are classified as *semi-crystalline.* The second class includes a series of granitic, gneissic and schistic rocks, which are thoroughly crystalline and without any determinable traces of their origin. The latter, therefore, are classified as *holo-crystalline.*

The main body of the semi-crystalline rocks of the Crystalline Belt is confined to a region bordering on the Paleozoic. Its northwestern limit is the Cartersville Fault; its southeastern, the beginning of the "holo-crystalline" rocks. In the small map on p. 59, a temporary divisional line has been drawn between these two areas.

[1] C. W. Hayes; Bul. Geol. Soc. Amer., vol. II., p. 147, 1890.

[2] It will be of interest to note the possible fossil, discovered in the marble belt by Mr. S. W. McCallie, Asst. State Geologist of Georgia. The specimen was sent to Prof. C. D. Walcott, Director of the U. S. Geological Survey, who returned it, saying that he was not certain of its character, but thought it might be the fossiliferous remains of a gasteropod.

It is suggestive, rather than an attempt at accuracy; much more work will be required in this section, on account of the nature of the transition between them, before the latter can be hoped for; nevertheless, for present purposes, it is fairly accurate. Included in the semi-crystalline area are patches of intrusives, whose structural relations to the inclosing clastics have an important bearing on the evolution of the Crystalline Belt.

It is noteworthy that throughout the semi-crystalline area, wherever an intrusive occurs, the contact clastics show indubitable evidences of metamorphism. A single instance will be cited, because of its interesting nature and its proximity to the holo-crystalline rocks. Near the Tate marble quarries, Pickens county, McCallie[1] observed that apophyses run out from an eruptive basic mass close by, and overlap the marble at several points. The accompanying plate[2] shows one of these veins, intruded between gneiss and marble. The result of this contact was evidently the conversion of a clastic into a gneiss, and important physical changes in the marble, the most interesting and noticeable of which was the expulsion of the coloring matter, so common in Georgia marble. McCallie found that this was true of every similar occurrence.

Principally, the rocks of the semi-crystalline area are mica-schists, usually soft, and bedded slates. All dip to the southeast, and strike about 20 degrees west of south. The dip ranges from 15° to 60°, with an average dip of about 30°.

To the southeast of the semi-crystalline area, and transitional with its formation, lie the holo-crystalline rocks. Gneiss is the prevailing type. Interstratified with the gneiss, in certain portions of this area, a few beds of semi-crystalline rocks have been observed, such as the belt of limestone running through Habersham and Hall counties, the quartzite of Tallulah Gorge, and the phyllites of Lumpkin county. Breaking through the holo-crystalline rocks, a belt of outcroppings of basic magnesian silicates, containing the corundum of Georgia, extends from North Carolina through Geor-

[1] See Bulletin No. 1, Geological Survey of Georgia; The Marbles of Georgia, by S. W. McCallie, p. 40.

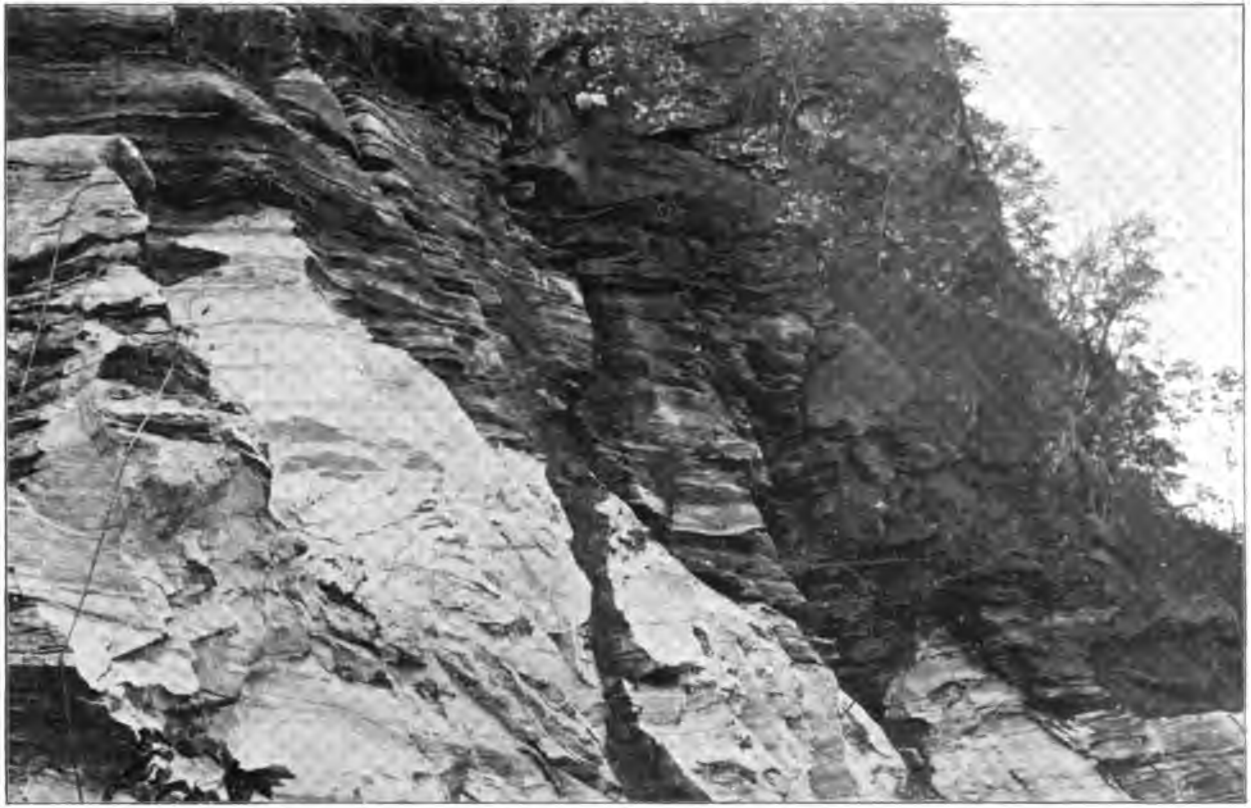
[2] See Plate II.

gia into Alabama. These eruptive masses are most numerous west of the Chattahoochee river, close up to the "semi-crystalline" line. Although some are found east of the river, as far as Monroe, Walton county, *none* occur in the semi-crystalline area. These physiological facts are significant in the study of the evolution of the Crystalline Belt. The presence of clastics among holo-crystalline rocks tends to confuse the opinion, that this area represents the fundamental complex. The disappearance of these corundum-bearing formations points to a time of deposition of the semi-crystalline rocks, later than these intrusions, while their continuity along a definite belt is suggestive of the force and direction of the great earth movement, that developed this line of weakness and permitted the welling up of so much igneous matter.

The strike of the holo-crystalline area corresponds with that of the semi-crystalline; but the dip is on an average much steeper and may be given as about 50°. Moreover, disturbances and alterations are more extensive in this region, than in the semi-crystalline. The sharp folds and faults, which must exist in such a folded area, are no longer noticeable. Rocks have changed their physical character; for instance, diorite has taken on a gneissoid structure; slates have changed into phyllites (mica-slates), and the mica-schists are harder than those of the semi-crystalline area. Even local metamorphism, consequent upon igneous intrusions, so noticeable in the semi-crystalline rocks, is little, if at all, apparent in the holo-crystalline rocks.

The apparent constancy of dip to the southeast throughout the whole Crystalline Belt is one of the most interesting structural features of the region. It shows, almost conclusively, that the entire area has been affected by a great orographic movement, the objective point of whose force was to the northwest, or at right angles to the present strike of the rocks. There can be little doubt, also, from the structural and physiological features of the Crystalline Belt, but that the force exerted its influence over a long period of time. The complex structure thus produced, erosion has effaced into a deceitful simplicity, that will always be a source of trouble to the economic worker. He must guard against taking, as the real

PLATE II.

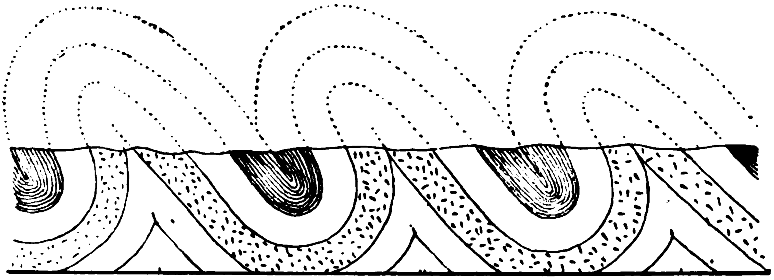


HORNBLENDE APOPHYSIS OVER MARBLE, NEAR TATE, PICKENS COUNTY, GEORGIA.

thickness of a formation, the measurement of its horizontal extent; for what appears as one bed, now that general erosion has removed the original surface, is in reality often a succession of beds. The complexity, moreover, is increased by metamorphism and superficial decay, which have wiped out, in a great measure, structural lines and similar evidences pointing toward sequence relations.

These facts are brought out in the following figure: —

FIG. 5.



Ideal geological section, showing the degradation of the tops of folds, and the direction of the force producing them.

This figure serves, also, to illustrate the method of determining the direction of force in simple earth movements. The longer slope of the fold is always toward the moving force; and, after erosion has removed the tops of the folds, only the longer slope remains, as the dip of the strata.

The structural features, which have been noted, may then be briefly summarized as follows: —

1. The "Cartersville Fault," which marks a time interval between the deposition of the semi-crystalline rocks of the Crystalline Belt and the Oostanaula Shales of the Paleozoic.

2. The apparent perfect transition between the semi-crystalline and the holo-crystalline rocks.

3. The absence, in the semi-crystalline area, of the magnesium-corundum deposition, which characterizes the holo-crystalline area.

4. The constancy of strike and dip of the rocks of the semi-crystalline and holo-crystalline areas.

5. The difference in degree of dip between the rocks of the semi-crystalline and holo-crystalline areas.

6. The absence of regional metamorphism in the eruptive portions of the holo-crystalline area, and its presence in the semi-crystalline.

7. The evidence, which testifies to an earth movement, preceding, and a continuous earth movement, following the deposition of the rocks of the semi-crystalline area.

From these observations on the structure of the Crystalline Belt, three hypotheses present themselves, viz.: —

1. That the semi-crystalline area is of the same age as the contact member of the Paleozoic, and that the holo-crystalline area is Archæan.

2. That the Crystalline Belt is older, than the contact member of the Paleozoic; that the divisions of the belt are of the same age; and that the holo-crystalline has the appearance of greater age, because of extreme metamorphism, brought about by igneous injections and concentrated dynamic forces.

3. That the semi-crystalline area is older than any member of the Paleozoic known in Georgia; that the corundum-bearing magnesian eruptives, were intruded prior to the deposition of the rocks of the semi-crystalline area; and that the holo-crystalline rocks formed a sea-floor for the deposition of the semi-crystalline.

The first two hypotheses do not conform to facts; but they are given, because they seem current.

The first hypothesis presumes to give an age to both areas; these ages, however, are at variance with the facts. The first fails to appreciate the Cartersville Fault, which represents an unmistakable time interval, because no cause could probably alter one part of an original series more than another, and produce such a great unconformity. The semi-crystalline area is evidently older than the Oostanaula shales. Again, in ascribing Archæan age to the holo-crystalline, present terminology[1] is undoubtedly violated.

The second hypothesis notices the time-break represented by the Cartersville Fault; but it does not permit of any interval between

[1] See Age of Crystalline Belt, p. 67.

the formation of the semi-crystalline and the holo-crystalline areas. It accounts for the difference of rock-character, by metamorphism, brought about by eruptives and dynamic forces. The seemingly perfect transition between the two areas tends to support the validity of this hypothesis. Opposed to it, however, is the disappearance of the corundum depositories at the semi-crystalline line; also, that lateral pressure from one direction, as shown by the strike and dip of the rocks, could have been sufficiently concentrated in one of the contiguous areas, to have removed evidences of contact metamorphism in one area and not in the other, especially at points close to each other.

Finally we are reduced to the third hypothesis, which presents conclusions more in accord with known facts, and may be held provisionally, until modified by later investigations. This views the Crystalline Belt as two distinct areas in point of age, and older than any other formations in Georgia. It considers the waters of the semi-crystalline sea to have washed the shores of a holo-crystalline continent already impregnated by the magnesian eruptives, in which we find deposits of corundum; and, further, that, at the time of the final uplifting of the semi-crystalline area, its formations, resting on the holo-crystalline sea-floor, which was being crushed and raised by the great orographic movement, were reacted upon, and the present sharp folding and faulting of the semi-crystalline area resulted.

AGE OF THE CRYSTALLINE BELT.

A conjectural age is still given to the rocks of this belt. Dr. Little,[1] State Geologist of Georgia, from 1874 to 1879, considered the whole area metamorphosed Lower Silurian. Dr. Spencer, in his last report,[2] maps the rocks of the Crystalline Belt, in contact with the Oostanaula shale of the Paleozoic, as metamorphic, and refers to them as questionably Lower Cambrian. The remainder of the belt he calls Archæan. Campbell and Ruffner[3] considered

[1] George Little, Report of Ga. Geol. Sur., 1876.

[2] J. W. Spencer, Geol. Paleozoic Group of Ga., 1893.

[3] A Physical Survey, extending from Atlanta, Georgia, across Alabama and Mississippi to the Mississippi River, along the line of the Georgia Pacific Railway, by J. L. Campbell and W. H. Ruffner, New York, 1883, p. 147.

the portion examined by them as Archæan, and distinguished the two divisions, Laurentian and Huronian. Since, however, no particular scientific examination of the area was made by any of these workers, except in detached areas, their statements may be taken as simply expressions of opinion, and not verified conclusions.

On the eastern slope of the Appalachian System, undoubted patches of Archæan rocks extend as far south as Virginia, and our geologies generally run them into Georgia.

With such data, the geological map of Georgia was compiled by the Agricultural Department in 1885; and thus the entire Crystalline Belt appears on the "legend" as Archæan. This, therefore, does not accord with any opinion, thus far expressed.

The prevailing opinion seems to be, that the Crystalline Belt is composed of rocks of at least two ages. The preceding section of this chapter coincides with this view. All the geologists, who have worked in the neighborhood of the Cartersville Fault, agree, that the rocks of the Crystalline Belt in that vicinity are metamorphosed clastics; and, if we may go so far as to infer it from their writings, they consider them of the Lower Cambrian. Until, however, more evidence is obtained to substantiate this age, which is probably correct, they may more properly be assigned to another period.

The greater portion of the Crystalline Belt, or what is here termed the *holo-crystalline area*, has been considered Archæan.

What rocks may be called Archæan?

Professor Van Hise, authority on Pre-Cambrian geology, in his exhaustive correlation bulletin, gives the following answer:[1]—"The Archæan is the basal complex of America. It has everywhere, if large areas are considered, an essential likeness. It consists mainly of granitic, gneissic and schistic rocks, among which are never found beds of quartzite, limestone or other indubitable clastics." He further adds, that their structural relations and the character of the rocks themselves show, that they have passed through repeated powerful dynamic movements.

[1] C. R. Van Hise, Correlation Papers—Archæan and Algonkian. Bul. U. S. G. S., No. 86, p. 13.

In the holo-crystalline area of the Crystalline Belt, are found, as cited [1] in the preceding section of this chapter, what Professor Van Hise would consider "indubitable clastics." If Professor Van Hise's definition of Archæan is accepted, the presence of such rocks in this area renders the assignment of Archæan age out of the question; and, if not, it at least makes this term objectionable, until better defined.

What age, therefore, can we properly assign to these two areas of the Crystalline Belt?

Rocks, heretofore, which, on account of their apparent clastic nature, could not be called Archæan, have been classified as Pre-Cambrian. American geologists now embrace the Pre-Cambrian clastics and their crystalline equivalents, under *Algonkian.* The Algonkian is limited, below, by the Archæan, and above, by the Cambrian. Sharp lines of demarcation are frequently impossible. Age has a tendency toward greater changes; nevertheless, removed regions of the same age may be unequally affected. In several areas, unconformities or structural breaks can be readily determined, while, in others, these distinct lines between the series will have been entirely wiped away, by metamorphosing influences. In this difficulty of differentiation, however, the Algonkian system is in no way different from other systems. In this period, we find time breaks, as in the others.

For these reasons, therefore, as an expression of our present knowledge, this entire complex Crystalline Belt may be provisionally assigned to the Algonkian period. Thus assigned, we are no longer involved in the absurdity of including known clastics in the Archæan; neither, if we have overlapped the Archæan or the Cambrian, have we done violence to our terminology.

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[1] See pages 63 and 64.

GEORGIA FORMATIONS.

Order.	System.	Series.	Formation.	Hayes' Equivalent.
I.	Pleistocene.	Columbia.	Columbia.	
II.	Neocene.	Lafayette. ?	Lafayette.	
III.	Eocene.	White Limestone (Upper Eocene). Claiborne / Buhrstone (Middle Eocene). Lignitic (Lower Eocene).		
IV.	Cretaceous.	Ripley. Rotten Limestone (?). Eutaw. Tuscaloosa.		
V.	Jura trias.	?		
VI.	Carboniferous.	Coal Measures.	Coal Measures.	Walden Sandstone. Lookout Sandstone.
		Lower or Sub-carboniferous.	Mountain Limestone. Floyd Shales. Fort Payne Chert.	Bangor Limestone. Floyd Shales. Fort Payne Chert.
VII.	Devonian.		Chattanooga Black Shale.	Chattanooga Black Shale.
VIII.	Silurian.	Clinton.	Red Mountain.	Rockwood.
		Hudson. Trenton. Chazy.	Chickamanga (including Rockmart Slate.)	Chickamauga Limestone.
		Calciferous.	Knox Dolomite.	Knox Dolomite.
IX.	Cambrian.	Potsdam (Upper Cambrian). Acadian (Middle Cambrian).	Oostanaula Shales.	Conesauga Shales. Rome Sandstone.
X.	Algonkian.	Georgia.	Semi-Crystalline. Holo-Crystalline.	Metamorphic.

GEOLOGY OF THE HOLO-CRYSTALLINE AREA.

The various rock formations, composing the Holo-Crystalline area, cross Georgia from the southwestern corner of North Carolina and the northwest side of South Carolina, and pass into Alabama about midway of the Georgia boundary, moving in a general southwest direction. Their course is practically straight, the strike being on an average 35° west of south. The dip is sometimes vertical; but generally it is sharply inclined to the southeast. In a measure, the structural features of the area conform to those of the Appalachian system; but the effacement of structural lines in many instances, their complexity, and extreme metamorphosed condition strengthens the opinion, that they have been subjected to late disturbances.

The rocks, thus far observed as making up the formations of the Holo-Crystalline Area, may be divided into eight distinct types. Three of these types, limestone, quartzite and slate, are indubitable clastics. Three of them are completely crystalline, namely, granite, gneiss and schist, and therefore exhibit no trace of clastic origin. Two are presumably of eruptive origin, and may be designated, according to their chemical and mineralogical composition, as peridotite and metamorphosed diorite or hornblende-gneiss.

The age of these rocks has been discussed in the preceding section of this chapter, and they have been assigned provisionally to the Algonkian. As was intimated, however, it is not impossible, that more thorough examination of this area will result in assigning a portion of it to the Archæan.

The prevailing rocks are gneiss and mica-schist. The mapping of these will require careful work, because of their alternating nature and easy transition from one to the other. The true bedding of these rocks has been more or less obliterated, and the existing structure is probably due to secondary foliation.

The youngest of these Algonkian crystallines are the eruptive. The peridotite type, which here includes the chrysolite and its alterations, steatite (soapstone), chlorite etc., is quite abundant in certain portions of this area.

These basic magnesian silicates sometimes occur in large masses; but they are usually found in Georgia, occupying small areas. Frequently, as elliptical-formed bodies, they stretch out several miles across the State, like a string of beads, with here and there a missing member. These are the formations, that are prospected for corundum.

It remains finally to speak of the intrusive (?) diorite or gneissoid hornblende. This type has been classified in this section as an eruptive; but sufficient proof has not been obtained to make it more than a probable assertion. It consists frequently simply of hornblende, usually with garnets; often it is feldspathic. The formations, if intrusive, are narrow *dykes*, stretching for miles across the country, and conforming to its general structure. Since their intrusion, they have been squeezed and folded, until now they present the characteristic gneissic structure. The breaking down of these dykes, consequent upon erosion, has spread the rotted material far beyond its boundaries, and hence gives rise to many of the so-called "red lands" of certain sections.

CHAPTER V.

DISTRIBUTION OF CORUNDUM IN GEORGIA.

POSITION OF THE CORUNDUM-BEARING FORMATIONS.
GEOLOGICAL RELATIONS OF THE CORUNDUM-BEARING FORMATIONS.
CORUNDUM VEINS.
VARIETIES OF CORUNDUM FOUND.
DESCRIPTION OF LOCALITIES.
ORIGIN OF GEORGIA CORUNDUM.

POSITION OF THE CORUNDUM-BEARING FORMATIONS.

The corundum deposits of Georgia are *thought of*, as lying within a narrow belt, whose width, as it enters Georgia from North Carolina, is limited to the region between the Laurel Creek corundum mine, Rabun county, and Brasstown Creek valley, Towns county. This represents a distance, east and west, of about forty miles. The belt is supposed to narrow down, and enter Alabama from Troup county.

The finding of corundum in North Carolina, Georgia and Alabama, about the same time, led those, who understood the trend of the rock formation of this region, to the natural conclusion, that there must be a continuous belt of corundum deposits extending through the State. Prospectors in Georgia, therefore, scarcely stepped out of this belt in their search. Their efforts, however, south of the mountains, were spasmodic, the depth of superficial disintegration making work difficult and unsatisfactory. In the mountainous counties, Towns, Rabun and Habersham, where the barrier to easy prospecting is at a minimum, the prospectors have confined the greater portion of their work. The boundaries of this zone have therefore been more or less mythical, especially south of the mountains.

With this knowledge to begin with, time not permitting of much detail work, the field season was spent in the so-called "corundum belt" and the adjoining territory, covering an area of 4,000 square

miles. Results of the work show, that the corundum zone has been too narrowly limited, and that it is by no means confined entirely to the mountainous district.

GEOLOGICAL RELATIONS OF THE CORUNDUM-BEARING FORMATIONS.

All the corundum deposits, thus far observed in Georgia, occur in basic magnesian rocks, whose type has been given as peridotite, including chrysolite, anthophyllite, serpentinized chrysolites,[1] schistose chlorite and steatite or soapstone. These form igneous intrusions along the stratification lines of the holo-crystalline rocks, the gneiss and schist showing by existing characteristics, that they were distended prior to the final folding of this region, and probably at a time, when the beds of these crystalline rocks were made a portion of the continent. The great earth movement, that uplifted the area, developed lines of weakness and cracks. These wounds nature healed, by an injection of igneous matter. A portion of the rents, thus produced and healed, now form the basic magnesian silicates, in which the corundum deposits occur. Earth movements, since, have concealed, in a great measure, the metamorphic influences of this molten material, and have likewise folded some of the peridotite alterations into corresponding relations with the schist and gneiss.

A matter of note is the constant presence of hornblende-gneiss, either on one side or the other of these formations. Such being the case, and since these gneissic-hornblende formations, varying from fifty to three hundred feet and more in width, are continuous for miles across the country, they act as an excellent guide in a search for the corundum-bearing formations. Gneiss or mica-schist seems always to surround the peridotites, or "chrysolite formations," as they are commonly called, the hornblende-gneiss[2] apparently never coming in close contact with the peridotites.

[1] A perfect serpentine has not been seen in any of the corundum formations of Georgia.

[2] See map of Laurel Creek mine, page 79.

CORUNDUM VEINS.

The Georgia corundum occurs in veins intersecting the peridotites and their alterations. Sometimes it occurs in the contact bodies, that is, in the gneiss, mica-schist or hornblende-gneiss; such an occurrence, however, has not been observed in Georgia. The veins vary in form, from those having practically parallel walls (usually inclined and descending to unknown depths) to simply lenticular pockets. In width, they have been found from one to twelve feet.

The matrix of these veins differs, not only in different, but in the same, localities. These four types have been noticed, viz:—

1. Lime-soda feldspar, with quartz and phlogopite; also with vermiculites, instead of phlogopite.
2. Lime-soda feldspar, with actinolite.
3. A course-grained aggregate of lime-soda feldspar and a black hornblende. Margarite is sometimes present in place of the feldspar.
4. A massive vein made up of a light grass-green amphibole (smaragdite), lime-soda feldspar and a little chromite.

All these types have their walls of compact, scaly chlorite, which quite frequently contain corundum. The first type is the most common; and, scattered through it, or, as is usual in the case of small corundum, in "bunches" or "pockets," occur the various colored varieties of corundum. In such veins, also, immense specimens of massive corundum are found.

The second type is apparently rare. In this, only small, irregular pieces of corundum have been found, and these usually possess an outer zone of some alteration (?) product of the corundum, usually margarite.

The third type is more common than the second; but it differs from the first two in its massive, pegmatitic character, and in its hardness. The feldspar and hornblende are both apparently little altered, and are about equally proportionate. Gray, grayish-blue, and slightly pink corundum are evenly distributed through the mass in irregular grains, varying from the size of a pea to several inches in diameter. Margarite has been observed in such veins, largely developed.

The fourth type is very rare. It is known only at one property in Georgia, and only at a few localities in North Carolina. The rock is made up of fine blades of smaragdite, of a beautiful light grass-green shade, feldspar, and small grains of pink and ruby-red corundum, profusely scattered through the mass. In Clay county, N. C., beautiful pink corundum occurs in the smaragdite, as veins, from a half inch to two and a half inches in thickness, sometimes with a slight coating of the lime-soda feldspar. On account of their beauty, these are highly prized as mineral specimens, the contrast of the ruby-red and the brilliant green being decidedly striking.

VARIETIES OF CORUNDUM FOUND IN GEORGIA.

All the varieties of corundum have been found in Georgia, with the single exception of emery. The principal is the variety, corundum, the non-transparent material of the corundum species. A few gems of the variety, sapphire, have been found at Hog Creek, near Hiawassee, Towns county. These were small, prismatic crystals of ruby color, but somewhat cloudy. A few gems of sapphire are said to have been found at the Laurel Creek mine in Rabun county; this report, however, is not authentic.

The corundum of Georgia is usually pink, gray or blue, these colors frequently occurring in the same specimen. Shades of red and light to dark-blue are common. White corundum is rare, and shades of yellow and brown have not been observed.

Georgia corundum is not uncommonly found in crystals; generally in six-sided prisms, and usually without terminations, though sometimes they are terminated by pyramidal faces. More highly modified forms have been found at the Laurel Creek mine. In the main, however, it occurs in small grains or blocks. Massive pieces, weighing several hundred pounds, have been taken from the Laurel Creek mine frequently, and much larger pieces are occasionally found.

DESCRIPTION OF LOCALITIES.

RABUN COUNTY.

General Observations.—The corundum properties found in Rabun county, up to the present time, are located in the extreme

eastern and north central parts of the county. Only one has been worked for corundum—the Laurel Creek mine; but this is famous throughout the country. Others have been worked for asbestus, and most all of them, on which corundum is known to occur, have received more or less attention.

The county is extremely rugged, being broken up by steep hills and high mountains; but some of the innumerable valleys are unsurpassed by any agricultural lands in North Georgia, for richness of soil and productiveness. Moreover, access to any portion of this most northeastern county is comparatively easy.

THE LAUREL CREEK MINE.

Corundum was first discovered on Laurel Creek, in the early seventies by an Englishman, named Thompson. Colonel Jencks followed this discovery by examination, and worked intermittently during 1873 and 1874. Altogether, only a few month's work was put in, and the "find" seemed so poor, that the property was finally abandoned. In 1880, several men, living in the neighborhood, mined it for asbestus. Their mining was much hampered, by the frequent occurrence of hard and heavy rocks, which they were forced to remove. The nature of these rocks was unknown to them; consequently they dumped them to one side. *This dump was Corundum.* Dr. H. S. Lucas of Chester, Mass., who, already had been, for some time, actively engaged in corundum prospecting through North Carolina, hearing of these works, visited the locality, and at once purchased the property for the Hampden Emery Co. of Mass., which, for some years, practically controlled the corundum industry of the United States.

Under the able management of Dr. Lucas, corundum veins were exposed, a plant was established, and what had formerly been a poor asbestus mine, soon became one of the main sources of supply to the corundum trade of this country. Work was continued from 1880 to 1892 with eminent success. In the latter year, the hillside, under which they were working the most paying vein, caved in, and for a time work was paralyzed. At this time, they had reached a depth of 130 feet, and were working in a vein averaging 8 feet in width. Up to the summer of 1893, work was carried on

unsuccessfully at other points, the owners report, while a shaft was being run down through the debris to the main vein. In September of the same year, the mines were closed down, pending the financial stress.

To this brief historical resumé, a few words may be well added, in regard to the advantages, which have accrued to the country, from this single industry. Besides the heavy taxes, which have been paid on the property, by this company, and the natural increase in value of neighboring lands, a small settlement has been established, in the heart of a heretofore sparsely settled portion of the country; new roads have been built, old roads have been improved, streams have been bridged, a saw-mill has been erected, and, by the generosity of the mine owners, three months have been added to the regular school term.

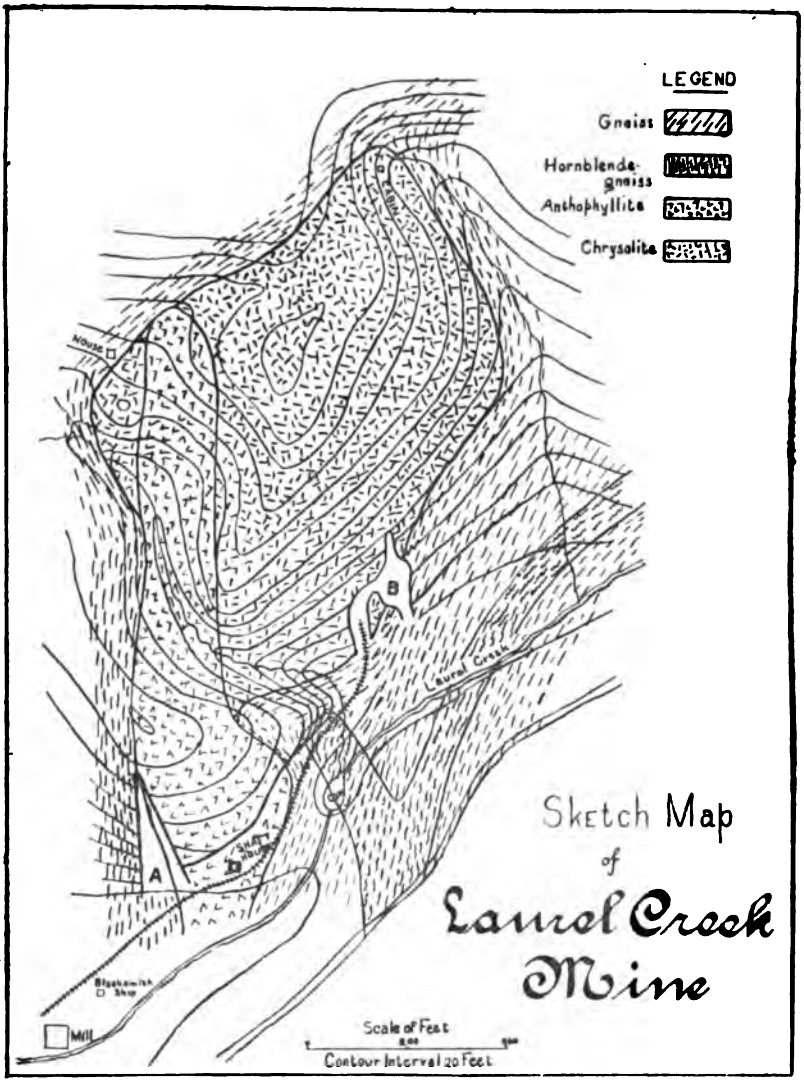
LOCATION AND GENERAL FEATURES OF THE MINE.—The Laurel Creek corundum mine, or "Lucas mine," as it is locally known, is situated in the southern portion of lot 72, 3rd district. Pine Mountain, the mining settlement, is about one mile southwest, and both are on the north side of Laurel creek, a small stream entering the west fork of the Chattooga river. It is for this creek, that the mine is named.

The sketch map [1] shows the position of the works, the relative position of the different formations, etc. From this, it may be seen, that the formation occupies two small hills. These stand out conspicuously to an observer, on account of their rough, barren nature and the rusty, ochre color of their rocky surface (so characteristic of chrysolite formations), offering, in external appearance, a sharp contrast to their environments.

The original works are represented in the "sketch map," by the irregular-shaped cut at the right, marked B. From a tunnel at this point, the immense crystals pictured in Fig. 2 were taken. From the same vein, have been also taken those immense specimens of massive corundum, for which the mine is famous. The triangular cut at the left, near the shaft-house, marked A, works

[1] See figure 6.

FIG. 6.



around the main vein, and is an excavation from the surface at the contact of the gneiss and the magnesian formation. This excavation extended around to the front of the hill, where the shaft-house

now stands; but it does not show on this map, because of the cave-in, already mentioned. The work of 1893 was an inclined shaft, running down to the base of this old excavation, a depth of 130 feet, and is located on the map by the shaft-house.

The mill of the mine is situated a few hundred yards southwest of the shaft-house. This consists of a stamp-mill and other machinery for crushing and cleaning the vein material. Water is the motive power, and this is supplied by a small mill-race, extending from a dam near the mine, along the hillside south of the creek, to the mill. Corundum in its matrix is transported to this mill, by means of a tram-way, where it is cleanly separated and packed in barrels; it is then hauled to Walhalla, S. C., a distance of twenty miles, where it is shipped to the Chester factory, in Massachusetts.

GEOLOGY OF LAUREL CREEK.

Three types of rock are represented at Laurel Creek: —

1. Gneiss.
2. Hornblende-gneiss.

3. Peridotite.	Chrysolite, with a little chromite. " more or less serpentinized, and associated with chromite. Anthophyllite.	Dunyte.

The position of all these types at Laurel Creek may be seen in the Sketch Map, Fig. 6.

Gneiss is the main inclosing body, and, as may be seen by the map, in the immediate vicinity of the magnesian body, its strike conforms to the shape of the inclosed mass. It consists of a schistose or stratified aggregate of feldspar, mica and quartz, differing from the mica-schist, in having a less foliated structure, and from granite, in the lamellar arrangement of its constituents. The stratification of the gneiss is accentuated by light and dark bands, sometimes several feet in width, with, occasionally, a pegmatite vein or a coarse-grained aggregate of the same.

At the contact of this gneiss with the intruded peridotite, we should expect a zone of metamorphosed material; but this is not visible. Evidently, therefore, this region has been much disturbed

PLATE III.

CORUNDUM AT BASE OF CHLORITE SCHISTS.
CUT AT BELL CREEK MINE, HIAWASSEE, TOWNS COUNTY, GEORGIA.

by earth movements, since the magnesian rocks became a part of its structure; and the original features have given place to later changes.

Hornblende-gneiss lies on the eastern side of the peridotite formation. Outcroppings occur on the south side of Laurel Creek, and northeast of the shaft-house, where the tram-way cuts the base of the hill. At the latter point, we find the limit of an extension, or apophysis, from the main body lying to the east. The cut at the tram-way also shows the curving strata of the hornblende-gneiss, as it conforms to the elbowing gneiss.

The peridotite body is seen to consist of two well divided areas. The northern hill consists mainly of chrysolite. Fresh material, taken from the cut at B, is composed essentially of massive chrysolite, with a small percentage of magnetite and chromite. Hand specimens show a rock of granular structure, the grains varying from minute to a quarter of an inch in diameter. In color, the rock is mottled-green. On freshly fractured surfaces, the chrysolite grains present a very distinct cleavage and a vitreous lustre. Microscopic sections show that the chrysolite is somewhat altered, by the presence of small serpentinized cracks, chlorite and magnetite.

A chemical analysis of this rock, by Dr. William H. Emerson, gave the following results: —

Chemical Analysis of Chrysolite.

SiO_2	42.71 [1]
MgO	41.18
FeO	6.83
Al_2O_3	0.70
NiO	0.32
MnO	0.09
CrO	trace
Ignition	8.38
	100.21
Sp. Gr	3.10

[1] The silica contains a small amount of chromite, which was not determined.

The exterior portion of this chrysolite body consists of compact, fine-grained, olive-green rock, with phenocrysts of calcite and the calcium-magnesium amphibole, tremolite. Through these rocks, also, are visible dark streaks of magnetite. A microscopic examination reveals, that the chrysolite veins are completely broken up by serpentinization and the development of magnetite and chromite.

The anthophyllite, which occupies the southern portion of the peridotite formation, and tongues north through the chrysolite, is supposed to be an alteration product of the chrysolite. It will be seen by the map, that this makes up about one-third of the entire peridotite body.

The rock consists essentially of fibrous anthophyllite, magnetite and scales of a bright green chlorite, with talc occurring in it, occasionally. Its color is brownish green. The specific gravity is noticeably heavy. On account of its fibrous character, it is frequently spoken of as "asbestus rock."

It is much to be regretted that, at the time of survey, the condition of the mine was such, that access to tunnels etc., was impossible.

Dr. Chatard, however, who spent some time at this mine preparatory to writing his bulletin on "The Gneiss-Dunyte Contact of Corundum Hill, N. C., in Relation to the Origin of Corundum," writes:—"The two localities are alike in respect to the occurrence of the corundum. In both, the mineral is found in chlorite and vermiculite, lying between hornblende-gneiss and altered dunyte. At Laurel Creek, the open cut, in which the corundum is mined, runs east 10°, 20° north, following the course of the veins, the mine being situated on the north bank of Laurel Creek, at the base of a high hill. On the south bank and in the bed of the creek, hornblende-gneiss is the country rock, succeeded as we go northwardly by enstatite, talc and allied minerals. The corundum, first met with, occurs in what is locally known as the "sand vein," which is composed of chlorite and vermiculite carrying more or less corundum, usually in small crystals and fragments. The chlorite in the upper portion of this vein was much disintegrated; the mass, falling readily to pieces, allows of the easy removal of the corundum; but, at the time of my visit, it was very compact and tough, and of little value. The sand

vein is succeeded by a so-called "horse" of steatite, on the other side of which is the vein of "block corundum." This is a vein of vermiculite containing masses of corundum, sparingly mixed with chlorite and vermiculite, and frequently of great size, several having been obtained, of at least 5,000 pounds in weight. One mass, which I saw, must have weighed at least a ton. The north wall of the block vein is a smooth wall of "indurated talc" and steatite, which gradually passes into altered, but still hard, dunyte. Indeed, the difference between this place and Corundum Hill is in no respect more marked, than in the greater hardness and toughness of the corundum-bearing rocks, and in the apparent concentration of the corundum into large masses, with but little evidence of crystallization. At the western end of the cut is a vein of decomposed white material, shown by analysis to be an altered soda-lime feldspar. In this, I did not find any corundum; but I was told, that it was occasionally found in this rock."

This description of those features, which he desires to bring out, would tend to confuse an observer. It will be seen by the map, that the hornblende-gneiss does not come in direct contact with the dunyte; but there is an intervening formation of gneiss. Moreover, the mineral, corundum, is not confined to vermiculite and chlorite, if the report of the miners is to be credited; but it is abundant in the lime-soda feldspar. The testimony was corroborated by the presence at the mill of several tons of feldspar, thickly studded with corundum.

THE HICKS ASBESTUS MINE.

Lot 81, 3rd District.

In the range of lots north, and cornering the land lot of the Laurel Creek mine on the east, is a formation, similar in character, known as the Hicks Asbestus mine. The formation, however, is much smaller apparently, a little over half as large. Corundum is reported to have been found here in small quantities; but the discoverers are said to have "salted" the property, with specimens from the Laurel Creek mine.

Considerable asbestus was taken away, and shipped, eight or ten years ago; and since then the property has been abandoned.

It is supposed to be a continuation of the Laurel Creek formation; but this cannot be proven by the outcroppings. It is true, that the same gneissic hornblende dyke passes on one side of these two properties; further than that, there is no connection.

LOTS 27 AND 28, 3RD DISTRICT.

This property belongs to the Nicholson heirs, living in the vicinity of Pine Mountain. It was worked for asbestus about the same time as the Hicks property.

The outcroppings are in the form of large bowlders of a talcose anthophyllite, similar to that found at the Laurel Creek mine; but outcroppings of like character may be found at intervening points, from Laurel Creek, alongside the same gneissic hornblende dyke.

This property is mentioned, because corundum is reported to occur here.

BEAVETT'S MINE.

Lot 177, 2nd District.

This property belongs to Capt. Beavett of Rabun Gap. The formation covers a little over an acre, and is made up of soapstone and anthophyllite. The development, which consists only of a "test-pit," is on the top of a little spur. Basic magnesian rock makes up the entire formation of this little spur, while on either side is gneiss. On the northeast side of the hill, hornblende-gneiss sweeps down, striking 35° west of south, and, with the gneiss, dips to the southeast.

At the bottom of the pit, under a large bowlder, several pounds of corundum were found in vermiculites. The largest crystals taken from this vein are not over one-third of an inch long and a quarter of an inch in diameter. All are prismatic, and thoroughly impregnated by scales of vermiculite. After this discovery, work was abandoned. On the same lot and the adjoining north lot, a larger and more favorable formation occurs.

LOTS 177 AND 188, 2ND DISTRICT.

The magnesian rocks on this property extend over about two acres, and are made up of chrysolite and anthophyllite. The strike of the formation is about 45° west of south. Its greatest width is

at the northeast, where it is about one hundred and fifty yards wide, measured at right angles to the strike. The formation maintains this width, as well as can be determined, for over two thousand feet, when it pinches out.

The country rock is gneiss. Hornblende-gneiss is also present, as with other formations of similar character in Rabun county. Both types of rock dip sharply to the southeast, and strike southwest.

Very little work has been done on this property; and, up to the time of survey in the Fall of 1893, no corundum had been found. At this time, Mr. J. A. Lamb and his crippled son, who live close by, were digging a few holes; but, having comparatively little knowledge of prospecting for corundum, their toil was fruitless. Following, however, the lines of rock pointed out to them by the writer, a few days' work opened up a vein eighteen inches wide, in which small granular and crystal corundum was quite abundant. The vein was of the first type, that is, a gangue of kaolinized feldspar, quartz and phlogopite. Two inch walls of chlorite inclosed the vein on either side. The corundum was found in "pockets," lying close to the west wall. No corundum was found in the chlorite wall. This vein is situated in the extreme northeastern part of the magnesian formation, and within a few feet of the contact with the gneiss. It increased in width, as the workmen enlarged the pit, and offered good prospects for a formation of this size. Only a few pounds of corundum were washed out, and then the work was left for the inspection of possible buyers.

The corundum taken from the vein is grayish-white, grayish-blue and dark-gray. It was without crystal form usually, and not encased by any mineral; hence it was easily cleaned from the vein matrix. The specimens in the possession of the Survey are minute crystals, of prismatic and pyramidal type, and irregular grains, all showing the characteristic lines of pseudo-cleavage.

LOT 157, 2ND DISTRICT.

In the lot on the north side of the ridge at Lucius Garland's house, is a large outcropping of peridotite, known to the neighboring people as "Soapstone Mountain." Its length on a north and south line is about 300 feet, its width 100 feet.

The outcropping consists mainly of talcose anthophyllite. Its country rock is gneiss and hornblende-gneiss.

This property is mentioned, because of its size and the fact, that no prospectors seemed to have worked upon it. This neglect by prospectors is due, in all probability, to the ignorance of its character, on the part of those acquainted with its existence, and to its inaccessibility. No corundum had been found here, at the time of our visit; but the property is worthy of investigation.

LOT 7, 1ST DISTRICT.

No corundum has been found in this district, and of the properties examined, only one seems worthy of special mention—lot 7. This property is said to belong to Dr. H. V. M. Miller of Atlanta. It was worked, several years ago, by Mr. Ashbury, for asbestus. Considerable asbestus is said to have been mined, before the work was abandoned.

This peridotite formation is about five hundred and fifty yards long and two hundred yards wide. It is made up, as far as can be determined, by outcroppings, entirely of chrysolite, changing into chromiferous chrysolite at the northeast. It differs, therefore, from other peridotite formations in Rabun county, by the absence of anthophyllite. The country rock is gneiss, while hornblende-gneiss lies close by, on the northwest side.

All the mining for asbestus was in the nature of deep open trenches, confined to the southwestern, and central portion of the formation, but some distance from the contact with the gneiss. No corundum veins were cut by these; and, in the light of present knowledge, this result is not surprising. Until, therefore, prospecting has been carried on, near the contact with the gneiss, this property should not fail, for lack of a little development.

TOWNS COUNTY.

The known corundum deposits of this county are confined to the western side of the 18th district, and the eastern and central portions of the 17th district. Those of the 18th and the eastern portion of the 17th lie within a few miles of Hiawassee, the county-seat, while the remainder are in Brasstown Creek valley and vicinity.

THE BELL CREEK MINE.

Lot 6, 18th District.

This is one of the richest and most interesting little properties in the State. It is located about four miles north of Hiawassee. Its extent, concealed by surface disintegration, exploration has not determined, since testing has been confined entirely to the outcropping, which is not more than one hundred feet in diameter. A short time previous to the survey, the walls of the main pit had been blasted in, by an irascible prospector, for fancied injuries at the hands of the owner. He did not disturb the dump, however, which is full of granular corundum up to the size of a half inch in diameter. In his mining, such small pieces were evidently considered unworthy of notice. From this, the nature of the veins was determined.

The outcropping is made up of chrysolite, anthophyllite and chlorite-schist. Gneiss and hornblende-gneiss form the country rock, as shown by the soil and by small outcroppings of the former, on the eastern side. The main pit, already mentioned, was about twelve feet in all dimensions, and was sunk through chlorite-schists. These are stratified, and dip about 45° to the southeast. The vein follows the stratification of the chlorite. Plate III shows one of the walls of this pit, with a small exposure of the vein, in the lower left hand corner. The gangue of this vein is kaolinized feldspar. This is rich in beautiful pink corundum. In the dump, pink corundum was found in the wall material (compact, scaly, dark-green chlorite); but, at this small exposure, it does not show, in the three-inch wall.

The dump of another pit (the pit itself was full of water) revealed the presence of the fourth type of vein—a massive aggregate of pink corundum and light green smaragdite with feldspar. As a

cabinet specimen, there are few rocks prettier than this. The owner of this property, Mr. Wm. R. McConnell, was not able to give any information, in regard to the character of its occurrence, which is unfortunate, since this is the only specimen of the class found in Georgia. Moreover, its presence seems to be confined to only a few localities in this country. The specimens, obtained for the Survey, differ slightly from material in our possession, from Buck Creek, North Carolina; the amphibole is a little lighter green, while the corundum does not attain the deep ruby color of the Buck Creek variety.

THE HOG CREEK MINE.

Lot 92, 17th District.

The Hog Creek mine is situated on the northwestern portion of lot 92, about two miles west, a little south, of Hiawassee. More work has been done on this property, than at the Bell Creek mine, because of its greater extent and prospects. A trench, east and west, exposes the character of the formation, and several pits have been dug in close neighborhood, in the search for veins. Despite these, there has been little development; and, although the prospects are bright, an approximation of its value will necessitate further development.

Pink corundum prevails here, as at Bell Creek; but the veins in sight are not so rich. It is from this mine, that the Georgia rubies were taken. The writer was informed by the owner, Mr. William R. McConnell, that those found by him were small prismatic crystals of good color, but cloudy. Blue and grayish-white corundum is also found here.

The vein now exposed is about four feet wide. It is of the first type, that is, a matrix of feldspar, quartz and phlogopite, and lies in chlorite-schist. Both the vein material and the chlorite-schist are much decomposed through superficial disintegration. Plate IV shows the vein with the inclosing chlorite-schist. The strike is about 30° east of north; and its dip is 70° southeast. The cut follows this vein about twenty feet, and goes down on it eight feet. Corundum is present, not only in the feldspar gangue, but also in the chlorite walls; when in the latter, it has a pink color.

Corundum Vein, Hog Creek Mine, Hiawassee, Towns County, Georgia.

Besides chlorite-schist, the formation is made up of chrysolite and anthophyllite; these latter show in the form of surface bowlders. Gneiss and hornblende-gneiss surround the formation.

From a mineralogical standpoint, this locality is interesting, in being the only corundum locality known in Georgia, where the mineral zoisite occurs. The specimen now in the possession of the Survey represents a portion of what was, before it was broken by the workmen, a surface bowlder of zoisite, encased in finely fibrous actinolite, over a foot in diameter. Sheets of the latter also spread through it, forming a base for the slightly radial, columnar arrangement of the needles of zoisite. Actinolite, in the form of minute light-green needles is, besides, occasionally found interlined with the needles of zoisite. Dr. Genth[1] has described zoisite as an alteration product of corundum; but no corundum is present on this specimen. In the future developments of this property, zoisite will probably be found *in situ*, and its relation to corundum may here be revealed.

On account of its rarity and the fineness of the specimen, an analysis[2] was made, with the following results: —

SiO_2	38.29
Al_2O_3	33.38
Fe_2O_3	1.51
CaO	24.19
MgO	0.93
Ignition	1.80
Alkalies	Undetermined.
Total	100.10
Sp. Gr.	3.35

Occurring on this lot, also, and as probably a continuation of the formation, is an outcropping of chromite, in which a chrome-ore vein has been opened. Genthite[3] is also present, as an incrustation on chromite. Some large blocks of feldspar, thickly studded with corundum crystals, were found in this cut, apparently *in situ*.

[1] See zoisite, page 46.
[2] Analysis by Dr. William H. Emerson.
[3] See page 56.

LOT 42, 23RD DISTRICT.

This lot belongs to Mr. J. N. Gibson of Hiawassee. Two distinct magnesian formations extend through it; and, on both, corundum has been found. In the fields southeast of his home, in the southwestern corner of this lot, a shaft ten feet square was sunk, several years ago. Corundum was found; but, the find not proving satisfactory, work was abandoned. Surface disintegration is quite deep here, and the only clue to the occurrence of corundum was its presence on the surface. In the northwest corner of the same lot, on a formation distinct from that of the southwest corner, a type of vein, different from any previously described, was exposed by Mr. Gibson. This vein is of the third type, and is massive-porphyritic in character. It is made up of large[1] hypidiomorphic crystals[2] of a black hornblende, with lime-soda feldspar, and irregular grains of grayish-white and blue corundum, frequently an inch or more in diameter. The hanging and foot walls are massive hornblende. Bowlders of this appear on the surface; but no outcroppings occur.

If this vein, which is about four feet wide, continues as uniformly rich in corundum, as present work forecasts, its economic value does not seem doubtful. Increase in the expense of working, as compared with that of the usual veins, will probably be compensated for, by the greater abundance of corundum.

OTHER CORUNDUM PROPERTIES NEAR HIAWASSEE.

Here are included lots, on which surface-corundum has been found; but no prospecting nor any attempt at development has been made. Outcroppings, if present, are small; and surface disintegration and "wash" have completely concealed the real extent of the formations. Following are the lots:—

Lots 4, 5, 34, 35, 36, 41, 43, 73, 17th district, and lots 89, 90, 91, 18th district.

[1] These crystals are often several inches in length and an inch or more in width.

[2] That is, crystals only partially bounded by crystal planes.

THE HAMILTON MINE.

Lot 60, 17th District.

The Hamilton mine is noted mainly for the lawsuit, in which it has been involved for several years past, and the large sum of money spent by Mr. Hamilton in its fruitless development, as brought out in court. It is located about five miles north of Young Harris, on a western spur of a range of hills forming the western boundary of Brasstown Creek valley, trending north and south, and culminating, at the south, in the highest peak in Georgia, Mt. Enota.

The works are located on the top of this spur, and consist of several prospecting pits, and a perpendicular shaft about 100 feet deep.

The formation is similar to that at Track Rock, though smaller. Its greatest width is in the saddle of the spur, pinching out rapidly, as it descends the spur on either side. The rocks brought out from the shaft are of the same type as those described at the Track Rock mine.[1]

The corundum, as at Track Rock, occurs encased in margarite. Sometimes the margarite scales lie flat upon the corundum, while other specimens show a zonal arrangement, with upturned edges, the latter type being more apparently an alteration of the corundum. Specimens of the actinolite-margarite rock were here found, containing corundum; otherwise the vein matrix for corundum was the same as at Track Rock. A section of the material penetrated by the shaft could not be obtained.

BRASSTOWN CREEK VALLEY CORUNDUM PROPERTIES.

These properties represent an almost direct southwest line of basic magnesian formations, extending through the Hamilton property, and connecting with the formations leading on to Track Rock, Union county. They occur on lots 23, 50, 60, 84, 85, 97, 118, 119, 135, 171, 190, 17th district.

[1] See pages 93 and 94.

UNION COUNTY.

Only a few deposits of corundum have been found in Union county, and these lie in the northwestern portion of the county. In this county, however, the almost continuous line of deposits of Brasstown Creek valley, Towns county, culminate in possibly the second largest peridotite formation in Georgia, the Laurel Creek mine ranking first. In this deposit is the Track Rock mine.

TRACK ROCK MINE.

Lot 259, 17th District.

Track Rock mine is located on the south side of Track Rock gap in the northeastern portion of Union county. The mine has been developed only partially; but already it shows excellent prospects. A large mill is conveniently located near the entrance to the tunnel. Water for washing the vein matrix is brought by an acqueduct from a little stream close by. The machinery, by means of which the company separates the corundum, is run by steam.

The present development is a tunnel to the right of the mill,[1] which enters the magnesian formation from its eastern side. The company has penetrated the formation about two hundred feet, branching out at several points. Although the tunnel is slightly inclined, to permit good drainage, they have, by this means, reached a depth of seventy-five feet from the surface level at the extreme end of the tunnel.

The formation differs considerably from the class of formations, represented by the Laurel Creek region. From a superficial inspection of this property, one would conclude, that the formation is made up of talcose-chlorite schists to the complete exclusion of chrysolites. Instead of a barren area of anthophyllites and serpentinized chrysolite, as at Laurel Creek, we are here confronted by a heavily wooded area, over whose rich soil are scattered large bowlders of a talcose chlorite or "blue soapstone," as it is locally termed.

The presence of corundum on such a formation tended to confuse preconceived ideas of the nature of corundum-bearing forma-

[1] See Plate V.

tions in the North Carolina–Georgia region. Corundum prospectors, moreover, have come to speak of the Track Rock mine as a "chlorite mine," in contradistinction to a "chrysolite mine." The Survey, however, found that these chlorites were simply a secondary feature, since most of the material taken from the tunnel, which had been passing muster for chlorite, was really a bright green amphibole, actinolite. Among the rocks taken from the mine, is a dark-green, finely granular rock, which was supposed to be massive chlorite.

This latter rock is most interesting, because it affords a key to the mystery of the formation. Instead of being massive chlorite, it is an altered chrysolite, consisting of fine blades of actinolite, small granules of chrysolite, and an abundance of magnetite. A thin section, examined under the microscope, shows that the chrysolite has undergone extensive change. Cracks in the remaining chrysolite grains are widely extended, and are filled in by actinolite (?), while small grains are completely isolated by enclosing actinolite. The large percentage of magnetite is also probably due to the alteration of chrysolite.

On account of the close timbering of the tunnel, it was impossible, at the time of survey, to see the sequence of formations penetrated, but the foreman, Captain R. J. Cook, who is now living on the property, had kept a record of these, from which, together with the dump and material obtainable in the tunnel, the following section was determined, viz: —

1. Thirty feet of micaceous gneiss.
2. Ten feet of talcose-chlorite schist.
3. Thirty feet of soft, greenish material and pearly white scales; the former, actinolite, the latter, margarite.
4. Four feet of hard, massive, dark-green rock, with gneissic structure, made up of actinolite and a lime-soda feldspar (oligoclase (?)). In this are bands of compact, scaly green chlorite.
5. Twelve feet of extremely disintegrated light-green material, consisting mainly of kaolinized feldspar, with a smaller proportion of light-green actinolite. Corundum is present in this.

6. Four feet of the same material as 4.
7. Twenty-four feet of material similar to 5. This is rich in corundum.
8. Four feet of material like 4 and 6.
9. Ten feet of material similar to 5 and 7, but not so rich in corundum.
10. Forty feet of lime-soda feldspar, in which hard bunches of feldspar remain unkaolinized. Mica (phlogopite) is scattered through this, but no trace of quartz.
11. Ten feet of talcose-chlorite schist.
12. Twenty feet of the soft, decomposed material like 5, 7 and 9, with some corundum.

The altered chrysolite, described on page 93, does not appear in this series; and, unfortunately, its position could not be learned.

Although, this section is doubtless wanting in considerable detail; nevertheless, from this series, such as it is, a few interesting and important facts may be observed:—(a) the new phase of alteration in the chrysolite; (b) the absence of anthophyllite rocks; (c) the presence, in close vicinity to each other, of broad parallel corundum veins; (d) the character of these veins; and finally, of marked significance, (e) the presence of these veins near the gneiss contact.

All the material, mentioned in the above section of Track Rock mine, may be duplicated at the Hamilton mine, and will probably be found, on the development of any of the corundum properties, extending through Brasstown Creek valley. The chrysolite of the Hamilton mine is of a lighter shade of green, than the one described here; but this is probably due to its less altered condition and its smaller percentage of magnetite.

The formation at Track Rock mine strikes southwest 30°, and dips to the southeast about 40°. The corundum veins lie in the stratification of this formation, and conform to its structure. None of these veins have been followed any distance; but, during the brief period of work, preceding the financial troubles of the summer of 1893, when work was stopped, several tons of corundum

were cleaned and shipped to the mills of the owners, "The New York Corundum and Mining Company."

The corundum obtained from the veins is in small irregular pieces, encased in a mantle of pearly, grayish-white margarite.[1] The process of cleaning and preparing this corundum for shipment will be described in the chapter on "Economics."

OTHER CORUNDUM PROPERTIES IN UNION COUNTY.

Lots 208, 244, 282, 295, 318, 17*th District.*

All these lots have been indifferently prospected for corundum. The amount found, however, and the lack of interest on the part of speculators has not enthused the owners to put any time or money into their development. Outcroppings of the basic magnesian rocks are small, if present; and deep surface disintegration characterizes the majority.

THE STONE MINE.

Lot 246, 17*th District.*

This property lies in the southeast corner of lot 246 on the north side of Track Rock gap, and on the east side of the road. It is a part of the Track Rock formation, and presents no differences, except in size. A twenty-foot tunnel, running from the road into the hillside, passes through talcose-chlorite schist into brownish-yellow banded, but completely disintegrated, material, through which, parallel with the band, are stripes of feldspar containing corundum.

The development is too slight to offer any assurance of its value. The formation, however, is large enough to induce further prospecting, and some good veins may be developed. This property belongs to Mr. J. H. Stevens, and it was under option to northern parties, represented by Mr. Robinson of Young Harris.

FANNIN COUNTY.

Corundum has been reported from this county; but no occurrence is yet known to the Geological Survey.

[1] This was determined by Dr. Emerson, from a partial analysis.

GILMER, PICKENS AND DAWSON COUNTIES.

Corundum is not known to occur in any of these counties; but it is quite possible that it may be found in Dawson.

LUMPKIN COUNTY.

Corundum was first found in Lumpkin county, in the summer of 1894. Only one locality is known.

Lot 249, 15th District, 1st Section.

About one mile southeast of the summer resort, Porter Springs, on the eastern side of lot 249, a low outcropping, seventy feet wide and two hundred feet long, was discovered by a child to contain corundum. This property belongs to Charles Cain, whose home is but a few yards from the outcropping. A prospector had given Mr. Cain's little boy a piece of corundum, with the injunction, "Dig for it in those green rocks, and make your fortune." The little chap went to work bravely, and his scratching was rewarded by a few pounds of grayish-white, blue and pink blocks of corundum.

The formation consists of massive hornblende. No work has been done to develop the property, and its size and prospects will probably not warrant the expense.

WHITE COUNTY.

Corundum has not been found in White county; but the corundum deposits of Habersham county are close to the northwest boundary; and, furthermore, basic magnesian formations continue on into White county from this vicinity, and are known to occur at several other points in that county. Careful prospecting will undoubtedly reveal in some of these the presence of corundum.

HABERSHAM COUNTY.

The first authentic knowledge of the occurrence of corundum in Georgia seems to have been the mention of a specimen from Habersham county. It is only in the past year, however, that an active search has been made for corundum in this county; but, in that brief time, its distribution is, perhaps, as well known, as that of any other section of the State. This is due almost entirely to the tireless energy of a few men, prominent among whom may be mentioned Mr. Thomas S.

TRACK ROCK CORUNDUM MINE, TRACK ROCK, UNION COUNTY, GEORGIA.

Bean of Clarksville, and Messrs. A. J. Lyons and William Trotter of Soque. The information of the latter is confined to the northwestern portion of Habersham county, while Mr. Bean is well versed in the mineral resources of the whole county.

The known corundum properties of Habersham may be said to lie in the Aleck mountains, a small range in the northwestern part, of the county. Despite, however, the number of occurrences in this section, there is not a property, which has been developed, and only a few, on which any work has been done. This is accounted for, not by reason of a lack of interest or faith on the part of those controlling the property, but on account of the unfortunate coincidence, that, at the time of discovery, capital was panic-stricken, and the corundum industry, in both North Carolina and Georgia, was at a stand-still. Nevertheless, when this industry is resumed, there is no doubt, but that some of these properties will receive careful attention.

PROPERTIES ON WHICH CORUNDUM HAS BEEN FOUND.

Lot 118, 11th District.

This lot is owned by Mr. E. P. West of Clarksville. Mr. E. T. Whatley, formerly Assistant State Geologist, had a small ditch dug across the small outcropping of peridotite in this lot, and he is reported to have found several pieces of corundum.

Lot.	*District.*	*Owner.*
125	*11th*	*E. Kimsey.*
126	"	*F. R. Asbury.*
127	"	*John Elder and John Tatum.*
131	"	*John Elder.*
132	"	*G. B. Elder.*
133	"	*Wm. Trotter, James Stroud, F. E. McCracken, Tillman Worley and E. Kimsey.*

In the lots enumerated above, some surface-corundum has been picked up; but no work has been done, except in the last. The formation extending through them, the outcroppings show to be chlo-

ritic; and it is probably similar in character to those of Brasstown Creek valley, Towns county, and Track Rock, Union county. Surface relations show this to be one hundred yards in width at several points. On lot 133, a trench 5 x 10 x 5 feet has been dug on the slope near the top of a small hill; and fifty pounds or more of beautiful corundum enclosed by margarite [1] has been taken out. The gangue of this corundum is reddish dirt, like the country material; and, on account of this superficial decay, it is impossible to tell anything about the character of the body, through which it is disseminated.

These specimens of corundum have attracted considerable attention, on account of their beauty. When taken from the pit, they resemble externally lumps of white clay; broken open, however, a nucleus of beautiful red corundum, with a zonal mantle of delicate pale-green margarite is revealed.

Lot 134 is interesting, on account of the presence here of a vein of the third type, consisting of black hornblende, lime-soda feldspar and corundum, as shown by surface specimens.

LOT 16, 3RD DISTRICT, LOT 129, 11TH DISTRICT, AND LOT 17, 16TH DISTRICT.

Through these lots, belonging to Mr. A. J. Lyons, a small magnesian formation extends, and several pieces of block corundum have been found while ploughing.

Information, in regard to any of these occurrences in Habersham may be obtained from Mr. Lyons or Mr. Bean.

HALL COUNTY.

Corundum is known in Hall county only at one locality. Beautiful red pieces of corundum have been found, for many years, by gold washers, in a small stream one mile west of Gainesville. Its source seems to have been recognized by a few; but it cannot be learned, that any specimens have been found, except in the sands of the stream. The locality has been well known to mineralogists for some time, not only on account of the beauty of the corundum, but because of the delicate green margarite found associated with it, an analysis of which, published by the chemist of the United States Geological Survey, is given on page 99.

[1] Determined by Dr. Emerson, from partial analysis.

The Survey examined this property in the summer of 1894, and found that the stream flowed by the eastern base of a small hill; that the backbone of this hill consisted of magnesian rocks; and that, at the northern end of the formation, in the ploughed field, north of the old road leading over the hill, corundum, associated with margarite, was abundant. Previous to this time, the presence of corundum on the hill had escaped the notice of its owners, because of the margarite mantle. There, the dull, dirty, nodular bowlders in the field—some of them as large as a man's head—failed to attract the attention of those looking for the bright, glistening, red corundum of the stream-sands below, when a blow of the hammer would have revealed the object of their search.

The specimens of this material, now in the collection of the Survey, range from one to six inches in diameter. Through these are scattered grains of corundum from a quarter to one and a half inches in diameter. Around these grains the margarite is zonally arranged; and, if not an alteration of the corundum within, it certainly resembles it.

The margarite in these specimens is grayish-white to a delicate pale-green in color. The zones are made up of small, pearly, radiating scales, with their edges tangential to the corundum nucleus. An analysis[1] of this mineral shows :—

SiO_2	32.15
Al_2O_3	49.28
Fe_2O_3	0.57
CaO	11.09
MgO	0.63
Na_2O	1.18
K_2O	1.04
H_2O	4.16
	100.10
Sp. Gr.	3.004

[1] Analysis made by Dr. T. M. Chatard, and quoted by Clarke, Am. Jour. Sci., 3rd series, Vol. XXVIII., 1884, p. 22.

The formation consists of pale greenish-white chlorite-schists and anthophyllite; large bowlders of the latter occur on the south side of the old hill road.

An analysis of the chlorite-schist was made by Dr. George A. Koenig, because, on account of its color, it was thought to be a talc-slate. He found it to be a true chlorite-schist, containing :—

SiO_2	30.33
Al_2O_3	20.90
Fe_2O_3	4.00
FeO	4.11
MgO	27.79
Ignition	12.62
	99.75

The strike of the chlorite-schist is 25° west of north; the dip is 45° to the southwest. This is a rare instance of the deviation of these structural features from the normal structure of the Crystalline Belt. Several deep pits have been sunk on the south side of the road, in an attempt to find good asbestus veins. This seems to have been a failure, the asbestus veins exposed being small, and the quality inferior.

The formation is about a quarter of a mile long and 100 feet wide. Though small, the abundance of corundum, that has been found here, should induce testing. Its close proximity to Gainesville, with her supplies and railroad conveniences, would probably sustain the development, even if the output was small, when a much larger mine would fail, for lack of such facilities.

This property is controlled by Major Theodore Moreno of Gainesville.

FORSYTH COUNTY.

The occurrence of corundum in Forsyth county was first noticed a year ago. Its presence here, except in one instance, is peculiar, in so far as the only known trace of its existence is its presence.

LOT 1,274, 2ND DISTRICT.

This lot is about one mile north of Sheltonville, and belongs to

Mr. Tuggle, Jr. Corundum has been found in his yard, both by himself and by neighbors, although mica-schist and garnetiferous hornblende-gneiss are the only types of rocks in the vicinity.

LOT 447, 1ST DISTRICT.

Corundum is reported to have been found on this lot; but its presence is very questionable.

LOT 776, 2ND DISTRICT.

Several little blocks of corundum were found by the writer on this lot, close by some small anthophyllite bowlders. Beyond the presence of these bowlders, all evidence of a basic magnesian formation is concealed. The occurrence is evidently of no economic importance.

CHEROKEE COUNTY.

A corundum deposit is reported east of Ball Ground; but we were not able to locate the property. It is quite probable, that some deposit will be found in the eastern part of this county. On Mr. S. J. Blackwell's property, lots 36, 37 and 108, 2nd district, 2nd section, there is an extensive formation of Pyroxenite (?), in which some large veins of asbestus have been exposed. Outcroppings of a similar character, but smaller, extend north several miles. No corundum has yet been observed.

COBB COUNTY.

In this county, corundum has been found only in the southwestern corner.

LOT 1236, 2ND SECTION, 19TH DISTRICT.

Mr. Elias Rogers, of Villa Rica, prospected considerably on this lot a few years ago, but without success. A little corundum is found scattered over the surface.

The property is owned by Mr. W. B. Westmoreland of Austell, Ga.

CORUNDUM IN THE VICINITY OF POWDER SPRINGS.

Surface corundum has been picked up in the vicinity of Powder Springs, on a "lead" extending from lot 684, which belongs to Mr. Henry Reeves, to Brownsville, Paulding County.

Outcroppings of basic magnesian rock are very rare, surface disintegration and wash, generally, concealing the formation. Only one point has been worked for corundum, a description of which is as follows: —

LOT 1271, 2ND SECTION, 19TH DISTRICT.

On the farm of Mr. W. B. Turner, about two miles south of Powder Springs, corundum occurs in workable quantities. At the time of the New Orleans Exposition, large surface specimens from this farm, which had been sent for exhibition, attracted the attention of a German syndicate, who, shortly afterwards, purchased the mineral interests of the property. Several months were spent in prospecting; and when a vein was finally exposed, work ceased.

This vein, between five and six feet in width, is of the first type. It lies between chlorite-schists, striking and dipping with the country rock. The strike is 50° east of north, and the dip 45° southeast. The vein is exceedingly rich in corundum, which is disseminated through it, in streaks, parallel to the dip of the vein, rather than in "pockets," and more thoroughly, than in any vein of this type, which has been exposed in the State.

The corundum of this vein occurs in small irregular grains, sometimes with crystal form. The color varies from grayish-white to blue and red. Its quality is eminently good. Surface specimens from this property often occur associated with blue kyanite.

Plate VI is reproduced from a photograph of the south side of the pit, showing the vein and the stratified chlorite-schists enclosing it. A geological hammer, with a 14-inch handle, stands in the center of the vein, for comparative purposes.

There seems to be no reason, why it would not pay to work this property. The vein is large, unusually rich, and can be easily worked for some time, on account of the disintegrated slate of the

matrix; and the property is within two miles of Powder Springs, a railway station, with an excellent wagon-road between the two points.

PAULDING COUNTY.

Corundum has been observed in the northeastern and southeastern corners of Paulding County.

On lots 533 and 534, 3rd district, 3rd section, and on the farm of Mr. William T. Prather, seven miles southeast of Acworth, surface corundum was found, a few years ago. This led to the purchase of the property by the Sapphire Valley Company of North Carolina. Since this prospecting, which consisted mainly of two vertical shafts, no work has been done by the company.

At the time of survey, these shafts were full of water; hence, the character of the formation penetrated is not known. There are no outcroppings close at hand; and deep disintegration marks the area.

The corundum is dark-blue and deep-pink in color, and is specially distinguished by strongly marked parting-planes and by its unusual softness. This latter property was overlooked, until a wheel, manufactured from it, was found to wear down with extreme rapidity under a piece of steel. Mr. E. W. Parker says:—"It is supposed that this variety of corundum contains a little water, as it is somewhat less hard and more easily cleavable than the common variety, known as sand corundum.[1]

Dr. Emerson, in the laboratory of this Survey, has made an analysis of a specimen of this corundum, with the following result:—

SP. GR.	4.20
Al_2O_3	94.58
SiO_2	1.77
Fe_2O_3	0.69
CaO	0.44
Water	2.51
	99.99

[1] Mineral Resources of the United States, 1893, pp. 676 and 677.

If this analysis be compared with the analyses of corundum by Dr. Smith,[1] it will be seen that the percentage of alumina in this corundum is very high, and the silica low, while the amount of water is lower than several; yet, the hardness of this corundum is between 5 and 7. Though readily scratched with a knife, it will itself scratch quartz. These facts lead to the suggestion, explanatory of this anomaly, of a possible secondary physical structure, which has greatly changed the cohesion.

CORUNDUM PROPERTIES IN THE VICINITY OF BROWNSVILLE.

In the notes on Cobb county, it is stated, that a "lead" extends from Powder Springs to Brownsville. This is based, in great measure, on hearsay evidence, since there has been no attempt at development along this line, except at W. B. Turner's in Cobb County. The southwest end of this "lead," or the last point, at which corundum has been found in the fields, is lot 456, 1st district, 3rd section, on Jacob W. Meadow's farm, a mile and a half south of Brownsville.

On account of the excellent prospect developed at Turner's, it is at least advisable, for the property owners, along this line, to interest themselves, in testing the lands, on which they find surface indications of corundum, since superficial disintegration and erosion have concealed the extent of these corundum-bearing formations; for a pretty prospect may be opened up.

DOUGLAS AND CARROLL COUNTIES.

Some surface corundum has been found in the vicinity of Villa Rica.

LOT 178, 6TH DISTRICT, DOUGLAS COUNTY, AND LOT 165, 2ND DISTRICT, CARROLL COUNTY.

The lot in Douglas county shows no outcropping; but that in Carroll county shows chrysolite and actinolite-talc outcroppings. The latter rock is made up of long crystals of actinolite, often as long as three inches and over one-third of an inch across, imbedded in pure granular white talc. Small veins of asbestus appear in the chrysolite.

[1] See page 30.

PLATE VI

Corundum Vein on Turner's Farm, near Powder Springs, Cobb County, Georgia.

On lot 118, 5th district, one and a quarter miles east of Carrollton, the county seat, close to the house of Mr. E. P. Worthy, corundum encased in margarite, similar to that found at Gainesville, was discovered by the Survey. A very small outcropping of chrysolite, with small veins of asbestus, occurs on the south side of the road. The corundum, however, was found in his yard on the north side of the road.

HEARD COUNTY.

LOT 44, 13TH DISTRICT.

This property belongs to Mr. William A. Hyatt, Central Harchee P. O. It contains a small formation of basic magnesian rock. From a small ditch across this, Mr. Hyatt uncovered several bowlders, weighing from fifty to one hundred pounds, and consisting of grayish-white and blue corundum in a matrix of black hornblende. Pink scales of margarite are also disseminated through the rock.

The size of the formation does not offer encouraging prospects; but the occurrence of corundum in this association is especially interesting.

TROUP COUNTY.

A short distance northeast of West Point, some northern parties prospected last year, over a narrow strip of peridotite rocks, which extend from the Chattahoochee River northeast, and outcrop intermittently, for about five miles. The object of their search was asbestus.

LOTS 286, 315 AND 316, 5TH DISTRICT.

The greater portion of the prospecting, mentioned above, was done on these lots, belonging to Mrs. N. H. Winston. Corundum has been picked up occasionally on these lots; and, from the dump of some of the pits, the writer picked up several small pieces of corundum, although no vein had been exposed, as well as could be determined from the character of the disintegrated material, forming the walls of the pits.

WALTON COUNTY.

It will be a matter of surprise to those, who consider the corundum deposits of Georgia to be confined to a narrow belt, following the course of the Chattahoochee River, to learn, that a deposit of corundum has been discovered in Walton County, some distance to the east of this belt.

LOT 160, 3RD DISTRICT.

Basic magnesian rocks are found at several points in Walton county; but, on this lot, the formation is quite wide. The only exposure is a small outcropping, composed of long, columnar crystals of bright-green actinolite in a slight matrix of steatite. At its widest point, the formation is about three hundred yards.

From this lot, over five hundred pounds of excellent block-corundum have been picked up, and shipped to the market. With the exception of a few small trenches, dug for asbestus, no effort at testing the property has been made. Nevertheless, the size of the property and the surface indications are encouraging for development.

The property is situated four and a half miles from Monroe, the county seat, through which passes the narrow gauge Social Circle and Gainesville Railroad. It is on the farm of Mr. George W. Breedlove.

ORIGIN OF GEORGIA CORUNDUM.

The study of the origin of corundum is still in its infancy. Scientists are not yet prepared, to offer more than hypotheses; for they have but started on that framework of facts, necessary to adequate theories and true conclusions. Hypothesis after hypothesis has been advanced; but only a few have sufficient foundation to justify second thought. Conservatism in conclusion, based on the few facts at our command, is therefore most necessary.

A single mode of occurrence is observed in Georgia ; that is, with the chrysolite formation extending through the Crystalline

Belt. The types of veins, containing the corundum occurring in these bodies, have been mentioned already in a preceding paragraph, as have also the geological environments of the chrysolites. Concerning the latter, it was noted: —

(1) That the chrysolite body occurred in gneiss or mica-schist.

(2) That in every instance, where it was possible to note the relations, hornblende-gneiss lay close at *one side* only; not enclosing the chrysolite, as stated by Julien[1] to be the case in North Carolina, nor in contact, as Chatard says, in his Bulletin.

(3) That the corundum-bearing veins lie in the chrysolite body, close to the contact, and in the vicinity of the hornblende-gneiss.

It has been observed, that, where all these conditions exist, corundum is present, often only in small amounts, and sometimes not at all. Corundum, therefore, seems to be essentially an accessory mineral, its presence being occasioned by an excess of aluminum present in the rock-masses, chrysolite, gneiss and hornblende-gneiss. Alterations of these yield, respectively, magnesium silicates, alkaline salts and ferro-silicates, which, together with the carbonic acid of the percolating waters, would dissolve the combined aluminum, and, on recrystallization, produce all the minerals mentioned as associates of corundum, and, in case of an excess of aluminum, the aluminum oxide, corundum. Predominence of any of the solution constituents would give character to the veins; hence the types which have been noted.

Chatard says: —[2] "Whether the solutions of soda and alumina must be heated, in order to effect the production of these minerals, is a question, to which, at present, no definite answer can be given; but it would seem, that the ordinary subaërial decay of these rocks should furnish the necessary solutions. The observations of Becker and the experiments of Barus show, that there is considerable doubt, as to any production of heat as a result of the kaolinization of feldspar; and, if such is the case with feldspar, it is not likely, that the alteration of any of the other mineral species present in these rocks

[1] A. A. Julien; The Dunyte Beds of North Carolina. Proc. Bos. Soc. Nat. Hist., Vol. XXII., 1882, p. 148.

[2] Bulletin 42, U. S. Geological Survey, p. 58.

would be attended by any marked rise in temperature. We must therefore conclude, that the gneiss can furnish an alkaline solution of alumina, and the dunyte, a solution of magnesia, without the production of heat, and, perhaps, without its aid."

Dr. Genth, from his admirable investigations of corundum, its alterations and associate minerals, concludes:—"That, at the great period, when the chromiferous chrysolite beds (part subsequently altered into serpentine etc.) were deposited, a large quantity of alumina was separated, which formed beds of corundum.

"That this corundum has subsequently been acted upon, and thus been changed into various minerals, such as spinel, fibrolite, cyanite, and perhaps into some varieties of feldspar; also into tourmaline, damourite, chlorite and margarite.

"That a part of the products of the alteration of corundum still exists, in the form of large beds of mica (damourite) and chlorite-slates or schists.

"That another part has been farther altered and converted into other minerals and rocks, such as pyrophyllite, paragonite, beauxite, lazulite etc."

The former hypothesis seems more in accordance with known facts; yet extended field-work and much laboratory investigation, concerning the nature of aluminum, in many instances so evasive, must be carried on, in the most careful manner, before we may hope to attain a tenable theory.

CHAPTER VI.

ECONOMICS.

HISTORY OF CORUNDUM MINING IN GEORGIA.
VALUE OF THE GEORGIA DEPOSITS.
PREPARATION AND MANUFACTURE.
STATISTICS.
HINTS TO PROSPECTORS.

HISTORY OF CORUNDUM MINING IN GEORGIA.

The history of corundum mining in Georgia is very brief. Only two mines have been operated in the State; and, at the present time, both are closed. The Laurel Creek mine began active work in 1880, and shut down in the summer of 1893. During the first twelve years, the production was eminently successful, and the mining of corundum in Georgia was considered an established industry; mining contretemps, however, followed by hard times, necessitated the cessation of work. The Track Rock mine is the other, which was operated in this State. Mining stopped here, a few months prior to the closing down at the Laurel Creek mine. Indeed, the period of mining was so brief, that it can be scarcely said to have been operated.

From several localities, corundum, generally picked up from the surface, has been shipped in small quantities, and prospecting has been carried on, in many places. The number of these prospectors attest the interest in the mineral displayed by the citizens.

VALUE OF THE GEORGIA DEPOSITS.

Individually, in certain instances, it would be unfair to attempt an approximation of the value of the corundum deposits of Georgia. In the majority of cases, little, if any, prospecting has been done; and, where there has been an attempt at development, such prop-

erties too frequently testify, that the prospectors had little aptitude for their work. Again, the formations are often obscured by subaërial decay and by detritus; they are also obscured by the cultivation of the soil. Until, therefore, the surface limits of the chrysolite formations have been defined, and prospecting has revealed the veins, whose decay left the insoluble corundum as evidence of their presence, just estimates are impossible.

Regarded as a whole, however, Georgia may well be proud of this mineral resource. It is probable, that very few large mines will be developed; but, for deposits of a mineral comparatively rare, and at present so much sought, for use in the arts, that the United States is not able to supply the home demand, the great number of small occurrences offer substantial hope for future revenue.

PREPARATION AND MANUFACTURE.

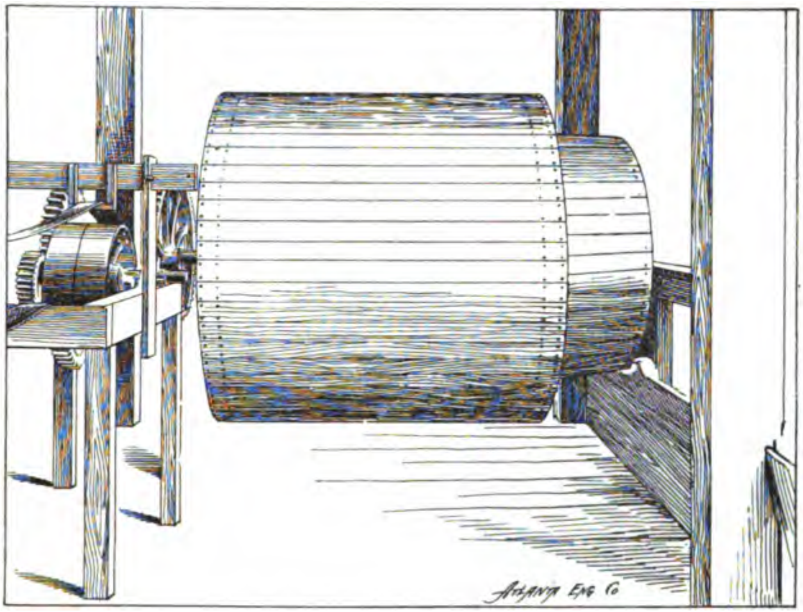
In the preparation of corundum, it is first necessary to free it from the accompanying gangue. If the gangue is hard, it is crushed, and then, like the disintegrated gangue, it is washed in a series of sluice-boxes or in a revolving washing-cylinder. The latter method of washing was devised by the Track Rock people, and is said to be a great improvement over the former method. The cylinder is barrel-shaped, and is about ten feet long and six feet across the largest part.[1] One end has an open neck attached, to permit the shoveling in of the material, while the cylinder is in motion. Into this end, also, a steady stream of water is introduced by means of a pipe. The other end of the cylinder is closed by a wire screen. A trap-door permits the ready removal of the corundum when cleaned.

The corundum at Track Rock mine cannot be thoroughly cleaned in this way, because of a hard zone of margarite around the corundum; hence it is introduced into another machine. This

[1] See Figure 7.

second machine is a small affair, as seen by figure 8. It contains two disks, armed with points, which are revolved with great rapidity. The zonal covering of the corundum, when exposed to this treatment, is worn off, almost completely.

Fig. 7.

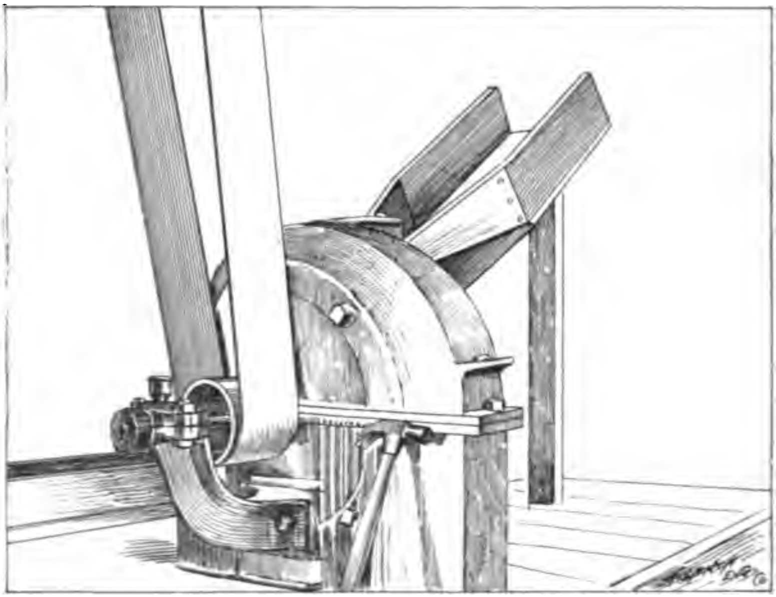


Corundum Washer Used at the Track Rock Mine, Union County, Georgia.

It is necessary, that all foreign substances be removed, since the material, to serve its purposes, must possess practically a uniform hardness. This is finally accomplished by further washing, in the series of crushings and siftings, which follow, in the reduction of the corundum to the various grades or "numbers." In this subsequent crushing, great care is exercised, to prevent the production of flour, since this is of much less value than the coarser grades.

The larger portion of corundum thus prepared is used in the manufacture of corundum wheels. In their manufacture, corundum is molded with some definite compound, of such a nature and so prepared, as to continually present a cutting surface.

FIG. 8.



CORUNDUM CLEANER USED AT THE TRACK ROCK MINE, UNION COUNTY, GEORGIA.

STATISTICS.[1]

The product of corundum and emery in the United States is from Rabun County, Georgia, Macon and Jackson Counties, North Carolina, Westchester County, New York, Chester County, Pennsylvania, and Hampden County, Massachusetts.

[1] Mineral Resources of the United States, 1893.

The following table shows the annual product of corundum and emery, since 1881: —

Annual Product of Corundum and Emery since 1881.

Years.	Quantity.	Value.	Years.	Quantity.	Value.
	Short tons.			*Short tons.*	
1881	500	$80,000	1888	589	$ 91,620
1882	500	80,000	1889	2,245	105,567
1883	550	100,000	1890	1,970	89,395
1884	600	108,000	1891	2,247	90,230
1885	600	108,000	1892	1,771	181,300
1886	645	116,190	1893	1,713	142,325
1887	600	108,000			

Emery Imported into the United States from 1867 *to* 1893, *Inclusive.*

Years ended—	Grains.		Ore or rock.		Pulverized or ground.		Other manufactures.	Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.		
	Pounds.		*Tons.*		*Pounds.*			
June 30, 1867	....	....	428	$ 14,373	924,431	$ 38,131	....	$ 52,504
1868	....	....	85	4,531	834,286	33,549	....	38,080
1869	....	....	964	35,205	924,161	42,711	....	77,916
1870	....	....	742	25,335	644,080	29,531	....	54,866
1871	....	....	615	15.870	613,624	28,941	....	44,811
1872	....	....	1,641	41,321	804,977	36,103	....	77,424
1873	610,117	$ 29,706	755	26,065	343,828	15,041	$ 107	70,919
1874	331,580	16,216	1,281	43,886	69,890	2,167	97	62,366
1875	487,725	28,345	961	31,972	85,853	2,990	20	58,327
1876	385,246	18,999	1,395	40,027	77,382	2,533	94	61,653
1877	343,697	16,615	852	21,964	96,351	3,603	....	42,182
1878	334 291	16,359	1,475	38,454	65,068	1,754	34	56,601
1879	496,633	24,456	2,478	58,065	133,556	4,985	....	87,506
1880	411,340	20,066	3,400	76 481	223,855	9,202	145	105,894
1881	454,790	22,101	2,884	67,781	177,174	7,497	53	97,432
1882	520,214	25,814	2,765	69,432	117,008	3,708	241	98,695
1883	474,105	22,767	2,447	59,282	93,010	3.172	269	85,490
1884	143,267	5,802	4,145	121,719	513,161	21,181	188	148,890
1885	228,329	9,886	2,445	55,368	194.314	8,789	757	74,800
Dec. 31, 1886	161,297	6,910	3,782	88,925	365,947	24,952	851	121,638
1887	367,239	14,290	2,078	45,033	*a* 144,380	6,796	2,090	68,209
1888	430,397	16,216	5,175	93,287	....	....	8,743	118,246
1889	503,347	18,937	5,234	88,727	....	....	111,302	218,966
1890	534,968	20,382	3,867	97,939	....	....	5,046	123,367
1891	90,658	3,729	2,530	67,573	....	....	....	71,302
1892	566,448	22,586	5,280	95,625	....	....	2,412	120.623
1893	516,953	20,073	5,066	103,875	....	....	3,819	127,767

a To June 30, only; since classed with grains.

HINTS TO PROSPECTORS.

"Show me corundum," an old corundum prospector says, "and I will show you corundum." The suggestiveness of this remark is at once apparent to any person, who has made a search for corundum. In other words, prospectors for corundum should be familiar with its associates. The knowledge, that chalcedony is an accompaniment of corundum, had aided the prospector, just quoted, in finding some of the prettiest prospects in Georgia.

Professor Jackson,[1] in 1864, finding margarite at an iron mine in Chester, Mass., predicted the occurrence of emery, which was discovered shortly after. At Rabun Gap, the writer discovered a corundum vein, by the presence of a thin seam of compact, scaly chlorite ; in Habersham, his attention was attracted to a small aggregate of black hornblende and feldspar ; other specimens of the same were soon found containing corundum. At Gainesville, he located the corundum, found in the stream, by margarite-mantled bowlders on the neighboring hill; and, from the presence of margarite, he discovered corundum east of Carrollton, in Carroll county.

Being assured of the presence of corundum by the associate minerals, and failing to find any specimens on the surface by simple inspection, proceed in the same manner as for gold, that is, pan the gravel. Good testing in this way should give favorable results; otherwise, there is little ground, on which to base hopes for a deposit worthy of further investigation. If corundum is disclosed, the next thing in order is to locate the vein or veins.

To accomplish this, it will be necessary, first, to determine the boundaries of the chrysolite formation; in other words, its contact with the inclosing formations. In some instances, the contact with these bodies will be apparent; in others, where the formation is obscured in ways previously noted, this may be accomplished, either by running a furrow, or, if necessary, a ditch, across the uncertain portions, *at right angles to the trend or strike of the formation.*

[1] Letter to Dr. J. L. Smith from Professor C. T. Jackson ; Scientific Researches ; J. Lawrence Smith, p. 48.

Finally, the contacts determined, confine work closely to those points near hornblende-gneiss, and keep a sharp watch for alteration and associate minerals of corundum. This caution is especially required, where the rocks are badly disintegrated.

The occurrence of corundum in the contact bodies has been observed by certain workers in North Carolina; hence, it will be advisable to also scan these critically.

CHAPTER VII.

AMERICAN LITERATURE ON CORUNDUM.

Very little has been published about corundum, either as to its mode of occurrence, or as to its origin ; and scarcely anything, except the most general statements, can be found in regard to the deposits in Georgia. The American literature on corundum is as follows: —

Adams, J. H.—" Corundum of Pelham, Mass., with Black Mica in Feathered Masses."
Am. Jour. Sci., 2nd Series, Vol. XLIX, p. 272.

Blake, W. P.—" Corundum in Crystallized Limestone at Union, Sussex County, N. J."
Am. Jour. Sci., 2nd Series, Vol. XIII, 1852, *p.* 116.

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Am. Jour. Sci., 3rd Series, Vol. IX, 1874, *pp.* 48–49.

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CHAPTER VIII.

SUPPLEMENTARY.

NATURAL AND ARTIFICIAL ABRASIVES.

NATURAL ABRASIVES.
- Pumice.
- Infusorial Earth.
- Tripoli.
- Buhrstones.
- Grindstones.
- Oilstones and Whetstones.

ARTIFICIAL ABRASIVES.
- Crushed Steel.
- Carborundum.

NATURAL ABRASIVES.

PUMICE.

Pumice is a spongy, vesicular variety of feldspathic lava, which owes its froth-like appearance to the tumultuous escape of gasses and steam, while it is yet in a viscous state. The bulk of pumice, used in this country, comes from Italy. Large deposits of it, found in California, are used to supply the demand on the Pacific coast. Quotations in New York for wholesale lots are:—

Select lumps @	\$ .03½–\$ .15	per	pound.
Original cakes @	.01½– .02	"	"
Powdered, pure, @	.01½– .01¾	"	"

Pumice is used principally for marble polishing.

INFUSORIAL EARTH.

Infusorial earth is composed of the extremely minute siliceous diatoms, the lowest order of unicelled plants. They form beds

upwards of thirty feet in thickness; and, according to Ehrenberg, a cubic inch of the material contains 40,000,000,000 shells. On account of its soft, chalky consistency, it is adapted particularly for fine polishing. Formerly infusorial earth was used chiefly as an absorbent of nitro-glycerine, in the manufacture of dynamite and other nitro-glycerine explosives, 25 per cent. of the product being infusorial earth. Now, in addition to abrasive purposes, it is used in the manufacture of soap; and it is coming into use in the manufacture of enamel brick, terra-cotta, fancy tiles and glazed-ware goods.

In the United States, it is mined chiefly in Maryland, Connecticut, Nevada, New Hampshire and New Jersey.

The following table shows the annual production of infusorial earth since 1880:—

Production of Infusorial Earth from 1880 *to* 1893.

Years.	Short tons.	Value.	Years.	Short tons.	Value.
1880	1,833	$45,660	1887	3,000	$15,000
1881	1,000	10.000	1888	1,500	7,500
1882	1,000	8,000	1889	3,466	23,372
1883	1,000	5,000	1890	2,532	50,240
1884	1,000	5,000	1891	....	21,988
1885	1,000	5,000	1892	....	43,655
1886	1,200	6,000	1893	....	22,582

TRIPOLI.

"Tripoli" is a term applied to a siliceous earth, which is mined extensively in Newton county, Missouri. It was first thought to be a species of decomposed quartz; but it is now considered a disintegrated siliceous limestone, from which the carbonate of lime has been leached out. The formation in Newton county is from ten to twenty feet thick, and covers over eighty acres, being the largest known deposit in the world.

On account of its porosity and absorptive qualities, the product is manufactured into water-filters and ink-blotters, which serve their respective purposes admirably. On account of its lack of iron, coarse sand or grit, it makes an exceedingly fine abrasive, when powdered, possessing a sharp cutting grain, that will polish

silver etc., without scratching. It is also used in the manufacture of soap and other cleansing preparations.

Henderson writes:—[1]"A tripoli or rotten stone, of excellent quality as a polishing material, is abundant near Dalton, and is found also in many other localities in this part of the State." Such properties should be investigated.

"The output from the mine" (at Carthage, Missouri,) "in 1892 was nearly 2,000,000 pounds, or 1,000 short tons of powdered material, and between 15,000 and 20,000 finished pieces of filter goods, the total value of which is estimated at about $30,000."[2] Work was continued on the property in 1893, and the output increased over that of 1892 about 25 per cent."[3]

BUHRSTONE.

A "buhrstone" is a cellular rock, very siliceous and exceedingly compact. The Tertiary deposits of the French basin have always afforded the best buhrstones, although American stones have served as well, for the coarser cereals.

In Henderson's report,[4] we find that the buhrstone, found in many portions of Southern Georgia, "has been pronounced by experts, as, in all particulars, equal to the best quality of French buhr. Also, that it exists in large quantities along and near the Savannah river, and at other points convenient to transportation. The stone varies from a light-gray to a reddish-brown color."

The buhrstone of Georgia occurs in the "Buhrstone Division" of the Middle Miocene series.[5]

This division extends from the Chattahoochee river at Early county, northeast to Burke and Screven counties, and on into South Carolina. According to Dr. Spencer, the extent of the buhrstone is limited in the mass, and is not confined to a single horizon.

The "roller process" in large mills has caused a decline in the

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[1] Commonwealth of Georgia, Part I, 1885, p. 139.
[2] Mineral Resources of the United States, 1892, p. 758.
[3] Mineral Resources of the United States, 1893, p. 679.
[4] The Commonwealth of Georgia, Part I, 1885, p. 138.
[5] First Report of Progress, Geol. Surv. Ga., 1890–91; J. W. Spencer; p. 149.

production of buhrstones, and this decrease will probably continue, on account of the introduction of emery-rock millstones.

The following table shows the value of buhrstones produced in the United States since 1880:—

Value of Buhrstones Produced in the United States since 1880.

Years.	Value.	Years.	Value.
1880	$200,000	1887	$100,000
1881	150,000	1888	81,000
1882	200,000	1889	35,155
1883	150,000	1890	23,720
1884	150,000	1891	16,587
1885	100,000	1892	23,417
1886	140,000	1893	16,639

The following table of imports shows, that the decline in the buhrstone industry has not been confined to stones of domestic production:—

Value of Buhrstones and Millstones Imported into the United States from 1868 *to* 1893.

Years Ended—	Rough.	Made into Millstone.	Total.	Years Ended—	Rough.	Made into Millstone.	Total.
June 30, 1868	$ 74,224	$	$ 74,224	June 30, 1881	$ 100,417	$ 3,495	$ 103,912
1869	57,942	2,419	60,361	1882	100,287	747	104,034
1870	58,601	2,297	60,898	1883	73,413	272	73,685
1871	35,406	3,698	39,104	1884	45,837	263	46,100
1872	69,062	5,967	75,029	1885	35,022	455	35,477
1873	60,463	8,115	68,578	Dec. 31, 1886	29,273	662	29,935
1874	36,540	43,170	79,710	1887	23,816	191	24,007
1875	48,068	66,991	115,059	1888	36,523	705	37,228
1876	37,759	46,328	84,087	1889	40,432	452	40,884
1877	60,857	23,068	83,925	1890	32,892	1,103	33,995
1878	87,679	1,928	89,607	1891	23,997	42	24,039
1879	101,484	5,088	106,572	1892	33,657	529	34,186
1880	120,441	4,637	125,072	1893	29,532	729	30,261

GRINDSTONES.

The Mineral Resources of the United States reports the main output of grindstones to be from Ohio and Michigan. The grindstones from Ohio are made from the sandstone of the geological formation known as Berea Grit. This underlies large areas in the northwestern part of Ohio, and takes on local names in different sections. Its color varies, in different localities, from white, brownish-white, grayish-white to yellowish-white; and its structure, from a fine and sharp grit to a coarse grit. The Michigan sandstone is blue, and possesses a fine, sharp grit. Both are used for sharpening edge tools.

The sandstones of Georgia have, up to the present, only local importance, although, for grindstone purposes, their fitness has been known for sometime. Henderson speaks of the itacolumite, or flexible sandstone, in certain localities, as affording "a suitable material, both for whetstones and grindstones, as do also some of the sandstones of Taylor's Ridge and of Chattooga and Lookout mountains."[1]

The annual production, since 1880, has been as follows:—

Value of Grindstones Produced in the United States, 1880 *to* 1893.

Years.	Value.	Years.	Value.
1880	$500,000	1887	$224,400
1881	500,000	1888	281,800
1882	700,000	1889	439,587
1883	600,000	1890	450,000
1884	570,000	1891	476,118
1885	500,000	1892	272,244
1886	250,000	1893	338,787

Grindstones Imported and Entered for Consumption in the United States, 1868 *to* 1893, *Inclusive.*

Years ended—	Finished.		Unfinished or rough.		Total value.
	Quantity.	Value.	Quantity.	Value.	
	Long tons.		*Long tons.*		
June 30, 1868	....	$ 25,640	....	$ 35,215	$ 60,855
1869	....	15,878	....	99,715	115,593
1870	....	29,161	....	96,444	125,605
1871	385	43,781	3,957.15	60,935	104,716
1872	1,202	13,453	10,774.80	100,494	113,947
1873	1,437	17,033	8,376.84	94,900	111,933
1874	1,443	18,485	7,721.44	87,525	106,010
1875	1,873	17,642	7,656 17	90,172	107,814
1876	1,681	20,262	6,079.84	69,027	90,189
1877	1,245	18,546	4,979.75	58,575	77,121
1878	1 463	21,688	3,669.41	46,441	68,129
1879	1,603	24,904	4,584.16	52,843	77,247
1880	1,578	24,375	4,578.59	51,899	76,274
1881	2,064	30,288	5,044.71	56,840	87,128
1882	1,705	30,286	5,945.61	66,939	97,225
1883	1,755	28,055	6,945.63	77,797	105,852
1884	....	....	....	....	*a*86,286
1885	....	....	....	....	50,579
Dec. 31, 1886	....	....	....	....	39,149
1887	....	....	....	....	50,312
1888	....	....	....	....	51,755
1889	....	....	....	....	57,720
1890	....	....	....	....	45,115
1891	....	....	....	....	21,028
1892	....	....	....	....	61,052
1893	....	....	....	....	59,569

a Since 1884 classed as finished or unfinished.

[1] The Commonwealth of Georgia, Part I, 1885, p. 139.

OILSTONES AND WHETSTONES.

"The most important whetstone grit, known in the State, is the novaculite of Lincoln county."[1] The most important stone found in the United States for oilstones and whetstones is "novaculite," which is mined principally in Arkansas. Its discovery in Arkansas, as a material fitted for abrasive purposes, was made sometime prior to 1818, and, since that time, its suitableness has become more and more apparent, as shown by foreign export. The term novaculite (*novacula*, a razor) is applied to a class of exceedingly hard, fine-grained, siliceous rocks, which are particularly adapted to whetstone purposes. The cutting power of novaculite is due, according to Griswold,[2] to the presence of innumerable small cavities—rhombic in shape, and resulting evidently from the leaching out of lime in the form of calcite—whose sharp edges, partially assisted by the frequent occurrence of large siliceous grains, with jagged outline, go to make up the abrasive face.

The Georgia occurrences of novaculite are found in McDuffie, Oglethorpe, Troup, Meriwether, Heard and Lincoln counties. In Lincoln county, it occurs as a low hill two miles from Lincoln Court-house, and projects nearly vertically from the ground, over an area of four or five acres. It has several colors. Where exposed, it is straw-colored; below the surface, it is greenish-white. This is the occurrence, of which Commissioner Henderson speaks, in such strong terms. It has been much used, locally; but it has never been quarried to any extent; whether on account of its inferiority, or for lack of investigation, is not known. Its presence, however, within the State is worthy of notice.

Included in the productions of the United States "are the two grades of novaculite from Arkansas, known as the Arkansas and the Wachita stone; the fine-grained sandstone of Orange County, Indiana, known as Hindostan or Orange county stone; a gray sandstone, known as Lake Superior stone, from Cortland County, New York; Chocolate stone from Lisbon, New Hampshire; and scythe-

[1] The Commonwealth of Georgia, Part I, 1885, p. 189.

[2] Annual Report, Arkansas Geol. Surv., 1890, Novaculites; by Griswold; p. 90.

stones made from Indian Pond and Lamoille sandstones, quarried in Grafton County, New Hampshire, and Orleans County, Vermont, and from Berea, Ohio, "grit."

Production of Whetstones etc., by the Pike Manufacturing Company in 1892 and 1893.

Kinds.	1892.		1893.	
	Output.	Value.	Output.	Value.
Wachita stone........pounds..	400,000	$ 60,000	300,000	$ 45,000
Arkansas stone........do.....	20,000	12,000	12,000	12,000
Labrador stone........do.....	500	50	200	20
Hindostan stone........do.....	800,000	15,000	250,000	13,000
Sandstone........do.....	100,000	2,000	100,000	2,000
Chocolate stone........do.....	20,000	2,000	20,000	2,000
Scythestones........gross...	16,000	50,000	13,000	40,000
Total........{ pounds... gross.. ...	856,500 16,000	141,050	682,000 13,000	114,020

Estimated Exports of Whetstones etc., in 1892 and 1893.

Kinds.	1892.		1893.	
	Amount.	Value.	Amount.	Value.
Scythestones........gross...	8,000	$ 20,000	8,000	$ 19,000
Wachita stone........pounds...	150,000	20,000	180,000	21,000
Arkansas stone........do.....	9,000	12,250	8,000	10,500
Hindostan stone........do....	75,000	2,250	100,000	3,500
Sandstone........	....	....	50,000	1,000
Total value........	....	54,500	....	55,000

Estimated Imports of Whetstones etc., in 1892 and 1893.

Kinds.	1892.		1893.	
	Amount.	Value.	Amount.	Value.
Turkey stone........pounds..	1,000	$ 200	1,000	$ 200
Scotch stones (all kinds)........do.....	8,000	800	4,000	400
Razor hones........dozen...	1,000	2,000	1,000	1,500
English scythestones,........gross...	50	300	25	150
Norway Ragg scythestones........	....	None.	....	None.
German emery scythestones........	50,000	1,000	30,000	500
Total value........	....	4,300	....	2,750

ARTIFICIAL ABRASIVES.

CRUSHED STEEL.

A prominent corundum mine owner and manufacturer informs the Survey, that the most prominent usurper of the corundum industry is "crushed steel." On account of the cheapness of the product, and the variety of uses, to which it may be put, it is for the present replacing much corundum and emery in the arts.

A concise description of this is given in the Mineral Resources of the United States, 1892, as follows:—"Another recent invention in the line of abrasives, to which attention has been called, by an interesting exhibit at the Columbian Exposition, is "crushed steel," manufactured by the Pittsburg Crushed Steel Company, limited, of Pittsburg, Penn. This product is obtained from crucible steel, highly carbonized, and made crystalline in structure, by manipulation in furnaces and chemical bath treatment. It is then reduced to small crystals, by crushing under heavy machinery, after which it is assorted into sizes by a system of sieves. The larger sizes, which vary from about the size of a No. 2 bird shot to one-fortieth of an inch, are classed as crushed steel proper, and used for sawing stone, particularly those varieties possessing hard and gritty qualities, such as granite, sandstone, marble etc. Grains, which pass through sieves, ranging from forty to one hundred and fifty meshes to the inch, are classed as "steel emery," and are used upon rubbing beds, and for polishing purposes. The finest product is, by an oxidizing process, manufactured into putty-powder and rouge, for polishing marbles, granites, agate and glass.

"The crystals of crushed steel and steel emery present sharp, cutting edges, having about the same angles as quartz, when crushed. They are exceedingly hard, and are more effective, under the saw blades and on the rubbing bed, than sand. The effectiveness of crushed steel and steel emery is due to the fact, that the crystals do not wear away and become smooth. A grain of crushed steel, under the microscope, presents a series of crystals; and, if sufficient force be applied, they are detached; but they main-

tain their crystalline form and abrasive qualities. For this reason the material can be used a great number of times, and in order to effect the greatest economy in its use, the manufacturers of crushed steel have also invented automatic attachments for saw gangs and rubbing beds, by which the steel once used is saved and returned. The efficacy of these products—crushed steel, steel emery, and the putty-powder and rouge—has been attested by stone-workers and manufacturers of lenses."

CARBORUNDUM.

An artificial abrasive, which has been attracting unusual attention lately, is termed by its inventor, Mr. E. G. Acheson, of Monongehala City, Pa., "Carborundum." The object of the invention was to produce a substitute for corundum and other abrasive materials. Reports as to its success have been contradictory. As a substitute for corundum, it thus far fails, mainly (1) because the manufacturers are not yet able to produce it as cheaply, and (2) because it lacks the toughness, being extremely brittle.

The description of carborundum, its manufacture, properties and uses, as given by the Committee on "Science and the Arts," of the Franklin Institute,[1] is as follows:—

"The method of manufacture consists in general, in subjecting to an extremely high temperature, and for a considerable time, mixtures of carbon with silica, or siliceous materials, and a suitable flux.

"The inventor finds, that the heat, generated by an electric current, affords him the most efficient conditions, for securing the high temperatures, needed to bring about the reaction, and accordingly states his preference for the use of the electric furnace.

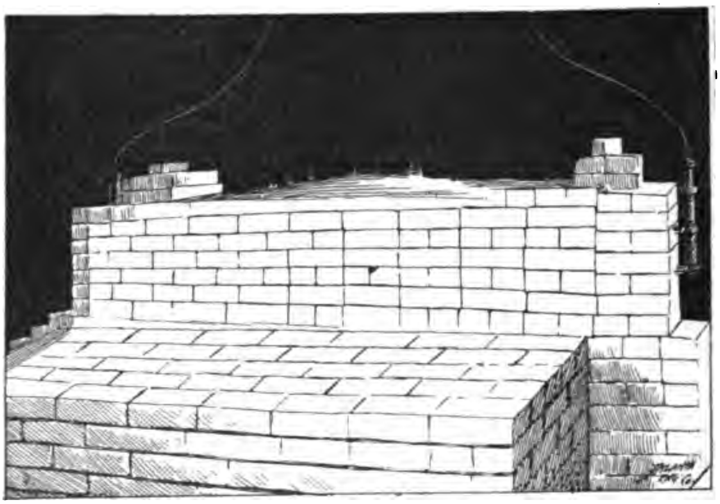
"The following general description will serve to explain the mode of operation:—

"An intimate mixture of carbon and sand is introduced into a rectangular box of brick or fire-clay, constituting the furnace chamber, the mixture being so placed, as to surround a core of granular carbon. Into each end of the chamber project several

[1] Journal of the Franklin Institute, Vol. CXXXVII, 1894, pp. 402–407.

rods of the carbon, making connection with the core, and, through these rods and the core, is passed a current, sufficient in quantity, and for a sufficient length of time, to fuse the contained silica, and bring about its subsequent combination with a portion of the carbon, to form a new substance, a silicide of carbon, to which the name of carborundum has been given.

FIG. 9.



ELECTRICAL FURNACE FOR THE MANUFACTURE OF CARBORUNDUM.

"Upon removal from the furnace, the carborundum is found as a porous cinder-like mass, formed of groups of small, glittering crystals of yellowish-green, bluish-green, or blue color, surrounded by more or less coherent masses of partly altered carbon.

"The separation of the carborundum from the other constituents of the mass is first effected, as completely as may be, by hand. The selected material is washed in water, then treated with acid, to remove soluble impurities (iron, alumina, lime etc.), again washed, then dried and crushed. By this means the individual crystals are separated, and the purefied material is then separated into commercial sizes of different degrees of fineness, by a process of float-

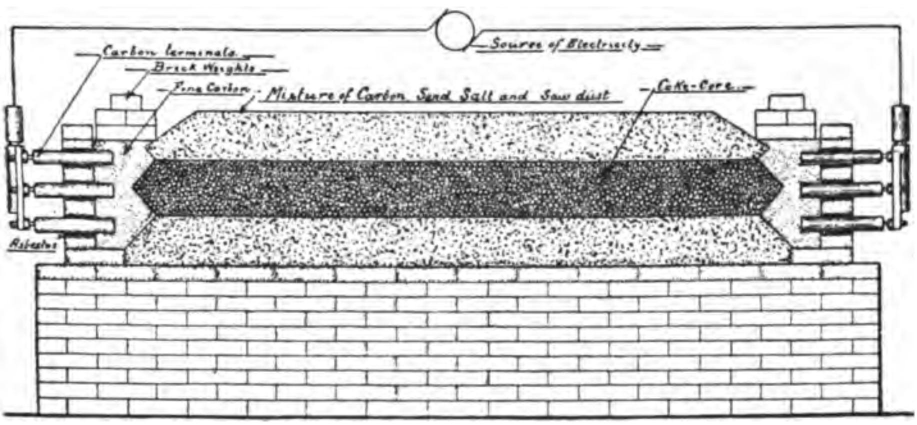
ation in a current of water, the several grades being thus automatically collected in separate receptacles.

"An analysis of the product thus formed shows, that it is a compound thus far new in chemistry, a combination of one atom of silicon with one atom of carbon, or, in chemical terms, a silicide of carbon, having the formula SiC. The re-action involved consists in the withdrawal, by the carbon, of two atoms of oxygen from the silica of the sand or clay, and the combination of the nascent silicon with a portion of the surplus highly heated carbon, according to the equation,

$$SiO_2 + 3C = SiC + 2CO.$$

"It is well known to chemists, that the formation of silicide of carbon, by the direct reduction of silica with carbon, has hitherto been impossible, at any temperature attainable in the laboratory. By the employment of the heating effect of the electric arc, in a furnace of the simple construction described above, in which the

FIG. 10.



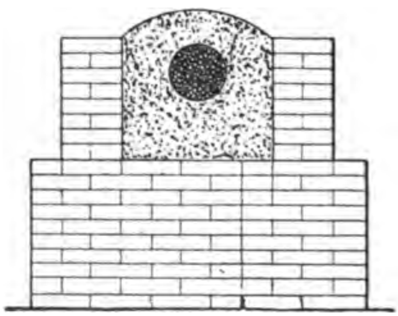
Longitudinal section through furnace before passage of current.

heat can be confined, the temperatures obtainable are so much greater, than can be realized by any other known methods, that re-actions heretofore deemed impossible are readily effected. In

the hands of Moissan and others, the electric furnace has lately been made to yield results of a nature, as extraordinary and unlooked-for, as those, which followed upon the first application by Davy of the voltaic battery, to effect chemical decompositions. In employing the electric furnace method, therefore, to bring about the desired results, Mr. Acheson deserves the credit of having applied the only method, by which it could have been successfully accomplished.

"At this point, it is worthy of notice that Moissan, whose recent experimental work with the electric furnace has greatly extended our knowledge of chemical re-actions, taking place at enormously high temperatures, produced this same compound (SiC), and described its properties, in a communication presented to the French Academy at the session of October, 1893; also, that Schutzenberger formed it, by the combined reducing action of *carbon and silicon* on silica. Mr. Acheson's results were obtained and duly announced, however, before the publication, by these investigators, of their results.

FIG 11.

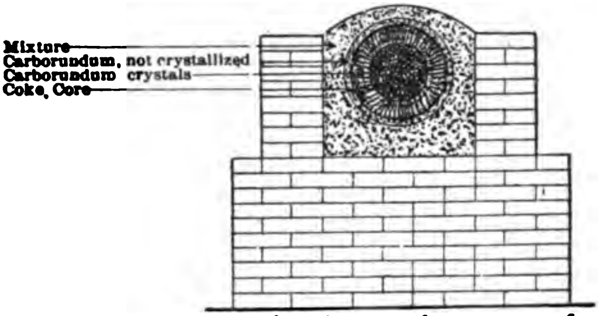


Section through furnace before passage of current.

"The interest attaching to this compound, because of its novelty and the mode of its production, is greatly increased by the remarkable properties, which it exhibits. Those properties, which are more particularly referred to, are the following:—

"*Permanence.*—Being formed at an enormously high temperature, it is natural to anticipate, that it would be stable, at all temperatures below that of its formation; but, in addition to this stability,

FIG. 12.



Section through furnace after passage of current.

it appears to be capable of resisting many of the most powerful chemical reagents. The only reagents, that appear to be capable of decomposing it readily, are the caustic and carbonated alkalies, in the state of fusion.

"*Infusibility.*—The substance appears to rank with the most infusible substance known, yielding only to the heat of the electric furnace.

"*Hardness.*—In this quality, the substance approaches, if, indeed, it does not equal the diamond, the hardest of known substances. This quality is one, which, at first, would not be readily recognized, being masked by the brittleness of the crystals.

"It is upon its hardness, that the present and prospective applications of the material are based. It is, in brief, as an abrasive material, for grinding and polishing metals, glass and precious stones, that carborundum has been found to possess decided merits; and, when its unique physical characteristics are so thoroughly understood, that they may be utilized to the best advantage, the material, in all probability, will rank among the most valuable abrasives known to the arts. It was first usefully applied, for the cutting and polishing of diamonds and other precious stones, and,

from reliable evidence presented in the course of this investigation, its cutting qualities will bear comparison with those of diamond-dust. It is reported to be specially useful for polishing such gems, and one of the members of the sub-committee charged with this investigation, having tested the merits of the material on various gems, reports very favorably upon it.

"It is used in considerable quantity, in the grinding of the glass stoppers and bulbs of the new Westinghouse electric incandescent lamps, for which service it answers very satisfactorily. It is found very efficient in certain finishing operations in machine work, as, for example, for brass valve grinding. Of late, it has been introduced in the form of small wheels, discs and points, for use in dentistry, in place of the corundum tools in general use; and, finally, it has just been introduced in the market in the form of wheels of large size, for general grinding and cutting purposes in machine work, as a substitute for emery wheels.

"The sub-committee charged with this investigation was supplied with a considerable number of samples of the material, in powder form and made up into wheels, with which to make trial of its usefulness. The results are given in what follows: —

"A number of wheels, of the sizes and grades indicated as most suitable for certain special uses, were sent to a number of machine shops, whose proprietors had expressed their willingness to test them. (Their reports form part of the record of this case, and are accessible for reference.)

"The results of the tests of these large wheels were very contradictory, the wheels being pronounced very satisfactory by some, and being condemned by others; but, in the main, the verdict was unfavorable. The absence of concordance in these results would seem to indicate the existence of faulty methods of manufacture, possibly the use of unsuitable binding material. It is certainly not unreasonable to assume, that, when more experience has been gained with carborundum, and its peculiar physical qualities are better understood, more uniform and better results, may confidently be looked for.

The smaller wheels and points, made for dentists' use, were found to cut porcelain much faster than wheels of corundum and shellac of the corresponding sizes and grit, and to wear away more slowly than the latter. When used dry, they cut faster than dry corundum wheels, and do not glaze so readily as these. This quality makes their use cleanly for the operator.

The results of these practical trials may fairly be summarized in the statements, that the new material possesses remarkable properties as an abrasive, being the first artificial substance, thus far produced, which compares favorably with bort in hardness, and which is capable of being used as a substitute for it; that, when its peculiarities are better understood, it should be capable of yielding cutting wheels of high efficiency, to take the place of abrasives in common use; and that it should find general application in the arts, wherever its price is not prohibitory."

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